ANATOMICAL MEMOIRS

OF THE LATE

JOHN GOODSIR.

John Goodsir.

THE

ANATOMICAL MEMOIRS

OF

JOHN GOODSIR

F. R. S.

LATE PROFESSOR OF ANATOMY IN THE UNIVERSITY OF EDINBURGH

EDITED BY

WILLIAM TURNER, M.B.

PROFESSOR OF ANATOMY IN THE UNIVERSITY OF EDINBURGH

WITH A BIOGRAPHICAL MEMOIR BY

HENRY LONSDALE, M.D.

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TO THE

Pupils of John Goodsir, F.R.S.

THIS COLLECTED EDITION OF HIS WRITINGS,

WITH A BIOGRAPHICAL MEMOIR,

IS

RESPECTFULLY DEDICATED.

PREFACE.

Soon after the death of the late Professor Goodsir several of his friends thought that it would only be a fit tribute to the memory of one who for so many years had occupied a prominent position as a teacher and man of science, to collect and arrange in an easily accessible form his published anatomical memoirs, most of which were scattered in Journals, or in the Transactions or Proceedings of various learned Societies.

On examining his manuscripts, it was found that amongst them were several lectures and essays carefully written out for the press, and in some cases even in proof, but which had not been published. From the new facts, or from the expression of opinion on questions of scientific interest, which they contained, it has been decided to include them in this collected edition of his writings. The duty of selecting those lectures and memoirs which were considered most worthy of preservation in this form has been under-

taken by Professor Turner, and in the editorial labour of correcting and revising the proofs he has had the most willing co-operation of the Rev. J. T. Goodsir, who has given every facility for examining the mass of accumulated manuscript, and has taken the most active interest in the progress of the work.

The papers are arranged, not in chronological order, but according to their subject-matter. In the first volume will be found a number of lectures on anthropological and psychological questions, none of which have previously been published; and several memoirs on descriptive comparative anatomy, of which the essays on Tethea, and on a New Mollusc, have not previously appeared in print. Two papers, written conjointly with the late Professor Edward Forbes, and a brief Appendix containing some detached observations selected from his note-books, close this volume. The second volume contains memoirs on development and morphology, together with a number of papers on anatomy, physiology, and pathology. Of the papers in this volume, most of those on the mechanism of the joints are new. The configuration of articular surfaces, and the movements of the joints, had been for many years the subject of careful study by the late Professor, and in addition to the essays on the knee and hip, his

papers contained notes on the structure and functions of various other joints, more especially the vertebral and costo-vertebral articulations, but they were unfortunately in too fragmentary a form to be made use of. In this volume also are incorporated three short papers by Harry D. S. Goodsir, which originally appeared in the volume of Anatomical and Pathological Observations published in 1845 in conjunction with his brother John.

The duty of preparing the Biographical Memoir was originally undertaken by the Rev. J. T. Goodsir, who, after collecting some materials in illustration of his brother's early life, committed this part of the work to Dr. Henry Lonsdale, whose long intimacy with Professor Goodsir, and other members of his family, and whose literary skill, were regarded as eminently fitting him to perform this office.

The portrait is engraved from a photograph of the Professor when he was forty years of age.

The Editors beg to acknowledge the liberal spirit in which the Publishers have carried out the preparation of the two handsome volumes now submitted to the medical profession and the public.

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CHAPTER I.

INTRODUCTORY.

The Goodsirs of Fife and Anstruther—Three generations of "Doctor Johns"—The birth, schooling, and St. Andrews education of John the Professor.

THE city of Edinburgh is built on lofty heights, acclivities, and intervening valleys; it is situated in the midst of sea and land prospects of great diversity and beauty; and naturally and æsthetically it shows the most picturesque metropolis in Europe. Its Old and New Towns form an architectural counterpoise; the Old, with its many-storeyed dwellings, narrow alleys, quaint turrets, its ancient Castle on precipitous rock, its royal Palace on meadowed plain—partaking more or less of the semi-mediæval, the transitional and the grotesque in art—stands in strong contrast to the uniform streets, the pleasure-gardens, the palatial edifices, and noble monumental structures of the New, or modern city. Claiming the rapturous admiration of foreigners, and no small share of national homage, Edinburgh, as a city of historic note, has ever been the pride and joy of its educated, enlightened, and æsthetic citizens. The man of travel, surveying the truly grand panoramic view from the Calton Hill, will best

comprehend the claims of the Scottish metropolis to the title of "Modern Athens,"—as characterised by her position, her environs, and sea-approach,—though the analogy between the cities of the ancient Greek and modern Scot has been viewed by the historic scholar as resting upon the broader bases of learning, of literature, and the arts. The Calton Hill itself, not so inaptly compared (the writer may say from personal observation) to the Athenian Acropolis, as an eminence in proximity to the sea and enjoying matchless views, wants, however, the climatic favours of Greece—the glorious sunshine that sparkles over the waters of Attica and gilds the mountain-tops of Pentelicus; the Calton has its works of art, and notably its classic High School, but where are the Propylæa, the Erechtheum, and the Temple of the Wingless Victory? The Calton has its lofty Doric columns standing in architectural isolation, and imposing, as seen from afar, like "Sunium's marbled steep;" these columns, however, can hardly rank with the dilapidated yet ever noble Parthenon, which, despite Saracenic and Venetian bombardments, man's iconoclasm, and a twenty-three centuried exposure to "decay's effacing fingers," still manifests in its pristine structure the sublime grandeur of Greek art and the marvellous majesty of the Greek mind.

Looking northwards from the Calton, the observer notes, immediately beneath, the shipping town of Leith, the Firth of Forth, with its countless sail of fishing-boats returning from the sea-depths, like laden bees

to their coast-hives; and across the said firth the county, better known as the Kingdom of Fife, stretching from the Ochils eastwards to the German Ocean; then the isles of Inchkeith and Inchcolme—a physical landscape somewhat resembling the Saronic Gulf and its surroundings; whilst, turning southwards, his thoughts may rest with absorbing pleasure on Edinburgh itself, in recalling its roll of scholars, historians, and men of science, who helped in days gone by to unravel the ancient philosophy, and whose successors, consistently with the age of Progress, are now seeking to outstrip the Past in a more glorious Present of discovery, enlightenment, and philanthropy.

Upon the shores of Fife the Pict, the Roman, the early Christians and Norman ecclesiastics all played their part and left their impress; and when Fife enjoyed the proud distinction of being a Kingdom, the warlike Thanes, in daring and defeating the Norsemen, exhibited faithful types of a stern Caledonian mediævalism,—so admirably adduced by Shakspeare in his Macbeth, one of the greatest dramatic and intellectual conceptions ever given to the world of letters. As Fife was a marked theological arena for John Knox, the rude citizen of Queen Mary's Court, the roost-destroyer of the Papacy, and albeit the mighty builder of a "Reformed Faith," so was it one of the cherished localities of the Covenanters, whose religious fever burned for martyrdom and death.* Fife being almost

* Nearly two-thirds of the population of Anstruther, it is said, perished in the cause of the Covenanters at Kilsyth and Sheriffmuir.

central to the "Highlands" and "Lowlands" became intimately bound up with the general history of Scotland from the period, far distant, of its Keltic aborigines, down to the Roman innovator and the monkish settlers, with whom, as the ancient ballad would have it—

> "The King sits in Dunfermling toune
> Drinking the blude-reid wine ;"

and whilst it shared in the warlike attitudes and theological feuds of the nation at large, it took the initiative in industrial pursuits, and, with a loyalty worthy of a better following, held to the last by the Stuart cause. At a later date, with the close of the 18th century, Fife felt the varied impulses that swayed Scotland in happy bondship with England—to-day improving its material resources ; to-morrow solicitous about its commerce menaced by France or Spain ; and on Sundays, all the year round, keenly alive to ecclesiastical polity and the fresh indoctrination of her pulpits.

On the south-east coast of Fife are two small shipping ports—Anstruther "Easter" and "Wester"—holding the position of royal burghs from 1583-7 down to 1832, when they were united with Cupar and St. Andrews in a single Parliamentary representation. "Easter" Anstruther, which affects this narrative, and in population has seldom exceeded 1000 inhabitants, has its business limited to boat-building, dyeing, and coast fishing. This Anstruther, or "Anster," had its traditions of naval encounters when Fife saw "the

Norweyan banner flout the sky," also its legends, its faiths, and its martyrdoms to be discursive upon ; but all these burgh boasts and local glories might have passed away with Fife mortalities had not Thomas Chalmers, D.D., the man of massive head and mighty work, orator, preacher, and political economist, and William Tennant, the poet and professor, been born within its little world. In the year (1814) that Scotland became cognisant, through Jeffrey's pen in the *Edinburgh Review,* of a youthful poet singing right cheerily, in the *ottava rima* measures of Boccaccio and Tasso, fancies based on the customs and characters of Fife, a third candidate for historical honours was born at Anster, named John Goodsir, who, along with Chalmers and Tennant, constitutes a triad of Anster worthies.

The Goodsirs of Fife have a family history of at least two centuries, and a credibly traditional life extending considerably beyond. Their progenitors are said to have come from Germany, and the old Scotch mode of pronouncing Goodsir as "Gutcher" would seem to favour the notion. The family had armorial bearings and a capital motto—*Virtute et Fidelitate*—than which no words could be found more applicable to the subject of this narrative. The big frames, the energy and steadfastness of purpose of the Goodsirs, a race trained to labour, ingenuity, and forethought, could hardly be reconciled with the *physique* and vivacious nature of the Celt, but seem to point to a strong Teutonic or direct Scandinavian origin—a supposition strengthened by the intercourse of the Norsemen with

the shores of the Firth of Forth—trading for cereals with the sons, and now and then espousing the daughters of Fife. Correctly or not, the nature of the soil is supposed to have a share in the product of manly growth and character; and the man of the East of Scotland is looked upon as taller and bigger-headed than the man of the West; consistently with this opinion the religious revolutions of the Scotch have arisen on the east of the country, and spread from a radius or central point over a large territory. Let their origin be what it may, the Goodsirs managed to keep themselves afloat in the world, and tried to meet bad harvests by garnering a little from the good ones. They were farmers, schoolmasters, and traders up to the eighteenth century, when the professional element became the prevailing one. The history of the family strengthens the Horatian tenet, and is not without the sanction of modern opinion that attributes physical and moral excellence to ancient stock. Thomas Goodsir of the seventeenth century may be noted as a prototype of his kinsmen. During the famine prevailing in his time, he helped his needy neighbours as long as he had it to give, and so freely as to draw forth a bit of his wife's mind:—"Ay, Tammas Gutcher" (repeating "Tammas" with a dogged meaning), "gie them'd a' and tak the blanket on yer ain shouthers."* Upon hearing this, Thomas would reply to his amiable spouse:—"My dame" (Scottish mode of addressing a

* Was the blanket thrown over the shoulder the token of domestic poverty and distress? or was it the significant garb of the old gaberlunzie of the seventeenth century?

wife), "ne'er fear, ne'er fear!" The Goodsirs were prone to marry, and, with quivers full, had large families of sons and daughters. Some of the latter readily found alliances when favoured, as they sometimes were, with handsome tochers of 1000 or 1500 gude Scots merks; in other words, dowries of a thousand or more silver coins, each valued at 13 shillings and 4 pence of English money. Many interesting details crop out of the family history, but only a few words on the direct line of doctors are allowable in this narrative, beginning with John, the grandfather of Professor Goodsir.

Nearly a century ago Dr. John Goodsir was among the best known men in the East Neuk of Fife. Born in the parish of Wemyss in 1746, he became a graduate of the University of Edinburgh, and settled at Largo. Known at home for his skill, affability, and other good parts, his essays in *Duncan's Annals of Medicine* gained for him reputation in the Edinburgh circle. This big-nosed, long-headed, large-hearted disciple of Galen and Lucina was a fine specimen of the eighteenth century country medical practitioner—hatted, coated, booted, and spurred, *à la mode.* Wiry in build, thoughtful and successful in practice, aye ready with his "mull" (*Scotticé* for snuff-box), and aye ready to help a neighbour as well as to uphold the interests and character of "canny Fife," he was among the most popular of men. The customs of the period were primitive and curious, and the practice of the healing art in rural districts was carried on in pack-saddle

fashion and regularity. Dr. Goodsir would start from Largo on Monday, caparisoned for the week with drugs and surgical appliances, and not return home till Friday—as itinerant with his physic as the ancient Peripatetic with his philosophy. He rode with a peculiar swinging motion that brought his spurs too frequently in contact with the horse; and after the spur-points were clandestinely cut off, the doctor still made the rowel play, causing marked solutions of continuity in the nag's sides. In his moods of abstraction, medical and theological, he overlooked the effects of hard steel upon soft textures. To obviate the dangers of travelling by night, he carried a lantern, fastened by a strap above his knee. The bull's-eye of the doctor's lantern was often signalled, in moonless nights, heralding the comforting assurance of an obstetric deliverance. His regularity in his rounds vied with the carrier of his Majesty's mails, and the saddle-bags of the one, and surgical accoutrements of the other, were similarly horsed, so that the Laird of Largo, scanning the roads, used to say,—"It's either the doctor or the post that's coming." His piety in time became as noted and demonstrative as his physic; for, after leaving "the Established Church," and having had experience of the "Independents," he joined the "Baptists" at Largo, and occupied their pulpit for twenty years! The Christian community looked upon him as "a physician by profession and a pastor by principle." His success in both directions led Fife folk to say that Dr. Goodsir's physic always did good, as it was mixed

with prayer. The *Evangelical Magazine and Theological Review* for June 1821 contains a portrait and biographical sketch of this worthy Æsculapian. "The church of Edinburgh" wrote to "the church at Largo," sympathising with the brethren on the loss they had sustained in the death of Dr. Goodsir, whose "savoury, and impressive, and edifying manner, as a pastor," was well known in the Scottish metropolis, and had frequently touched the hearts of both churches.

Dr. Goodsir of Largo married Miss Agnes Johnstone of Moffat, Dumfriesshire, by whom he had eleven children. His three sons took to surgery. John, the third son, settled down at Anstruther, where he became highly esteemed. He married Elizabeth Dunbar Taylor, daughter of the Rev. Joseph Taylor of Carnbee, whose wife was Jeanie Ross, daughter of Duncan Forbes Ross of Kindeace, and granddaughter of Grizzel Forbes, the sister of Lord President Duncan Forbes. This, the second Dr. John Goodsir, had five sons, three of whom are dead, and one daughter. The oldest son, named after his father, John, is the subject of this memoir, and was born on the 20th March 1814. The second son, Joseph, a scholar and divine, and his amiable sister Jane, are now living in Edinburgh; Harry, the third son, an anatomist and naturalist of the highest promise, joined Sir John Franklin's expedition to the Polar Seas in 1845, and perished with that noble band of heroes—martyrs to science and geographical discovery; Robert, the fourth son, graduated in medicine, and sailed twice to the Arctic Regions with Captain

Penny (in Lady Franklin's ship), in search of his brother Harry; and Archibald, the youngest son, studied medicine with eminent success in the best schools of Europe, and then came home to die—too truly a victim to his zeal in anatomical pursuits.

The Goodsirs of Anstruther had formed family ties with—1*st*, the historical Forbes of Culloden—many letters of the Lord President Forbes are now in the Goodsirs' archives; 2*d*, with John Monro of Milton, the father of Dr. Monro, *Primus* and founder of the Anatomical School of Edinburgh; 3*d*, with Dr. John Gregory of Aberdeen, and his son Dr. James, the author of the *Conspectus Medicinæ Theoreticæ*, who, living in Edinburgh, became allied with the Rev. Archibald Alison, the "Man of Taste," and father of the historian of Europe, and William Pulteney, the distinguished professor of the University of Edinburgh; 4*th*, with Dr. Joshua Mackenzie, the father of Henry Mackenzie, the "Man of Feeling," and others of position in and around the Scottish metropolis. These direct and collateral blood-affinities of John Goodsir might constitute a pretty family chapter, in which the philosophic, the medical, and the historic, would find large space and mention; and his being linked with the Monros the most curious of all—the Monros who established the fame of the Anatomical Chair of the Edinburgh University, and continued to hold it for three generations, and then resigned their place and trust to him (John Goodsir), to uphold, extend, and dignify. The genealogical web of prominent Goodsir warp, with its skeins of chivalry

and law of the Culloden Forbes, forming an excellent fabric, showed a border of Monro-anatomical cord, fringed with the æsthetic Mackenzie and the medico-classical Gregories and Alisons.

The boy John Goodsir grew in stature and good sense, and partook of the tender reciprocations of feeling that seasoned the domestic hearth of a gladsome and kindly-conducted home in Scottish life. His mother was a person of superior education, who possessed many accomplishments, not the least of which was good management of her household and the affectionate guidance of her children. John used to recall his babyhood—his mother's coaxing him to try a dip in the sea, and of her guiding him so gently beneath the "bonny waves;" then the daisied field, so pearly and scarlet, in which he was allowed to romp; and, above all, he remembered the pure white lily, the presentation of which elicited his first word-utterance, to his own and others' delight;—verily a pleasant dawn of memory, happily associated with nature, and inchoative of a larger acquaintance with organic forms and a grander knowledge of the creative world. De Quincey wrote of his babyish memories as the earliest on record—startled, however, by a sudden burst of grief, the presage to a fitful and unsettled life of opium in high revelry and antipodal remorse; but Goodsir had his primitive cognisance called forth, and quite as early in life, by the open sea, daisied pastures, and liveried flora, and he lived to enjoy equanimity and pleasure in watching progres-

sive thought and extending the lines of science. John's character as a boy, his brother states, "was singularly pure and good, never defiled by bad language or mean and evil deeds. His activity of mind and sagacity, co-operating with a most kindly and just spirit, formed for him a constant safeguard. In one sense he never was a child or boy, for he was at no time the sport of mere childish or boyish inanity. But still he was as little, in early as in later life, in the least priggish or austere. He was an open-faced, warm-hearted, rather diffident boy and lad, even as through life he continued to be an honest, kindly, and unostentatious man." Good education and training fell to John Goodsir's lot. The worldly wisdom and Scotch caution, the love of home and of natural scenery, and the sea and its living things, were exampled to the juvenile Goodsirs, along with the moralities, the principles, and the virtues of correct life. John imbibed the hereditary feeling of his family for worldly distinction, and seems at an early age to have been gathering up his strength for the great conflict of life. On this head his brother very justly remarks:—"While natural force of character will always find or make its own way, and that apart from such force no circumstances can be of much avail, still the favourable or unfavourable traditions of a family, equally with those of a larger society, act most powerfully on the members, whether of the family or larger associations."

John was sent to the Burgh and Grammar Schools of Anstruther, and these, like other Scottish schools,

were noted for close surveillance, long tasks, and the hard grit of the instruction given; the Bible in daily use, and the Ten Commandments always in command, with Long and Short Catechisms standing as awful monitors in the foreground of puberty. In his thirteenth year he was sent to the University of St. Andrews, where he speedily attracted notice by his assiduity and forwardness as a scholar. He went through the regular *curriculum* required for a degree in arts; and though the "Humanities" partook more of a High School form than a true University, the years of study spent within its walls were viewed by him as exceedingly profitable and formative of character. There was the daily work, the hebdomadal exposition of each lecturer, and other helps to systematic and scholarly pursuits; and these served as an instructive basis and no less wholesome training to his diligent and ever-appetising mind. To be put in the right groove for acquiring knowledge was, to a lad like John Goodsir, more than half-way to the accomplishment of the task assigned him. Dr. Chalmers was Professor of Moral Philosophy at this time; and as the Professor and student had both family and nativity ties, a pleasant relationship existed between them. In May 1827, when fully thirteen years of age, John had mastered the first twenty propositions of Euclid, and was reading the "Clouds" of Aristophanes in the Greek. He showed a greater aptitude for Latin than Greek or mathematics; but as he was not one-sided, even in his

juvenile days, each branch of study obtained equal attention at his hand, and few of his college companions were much ahead of him. In the last year of his studies at St. Andrews he attended a course of lectures on natural history given by Mr. John G. Macvicar (then a licentiate of the church, now D.D., and the accomplished minister at Moffat), and formed friendships with those of congenial tastes to his own; and though so young, joined a scientific society, in which several lads of promise were enrolled. Mr. Macvicar's lectures embraced a general course of natural history, and were much more than suggestive of first principles. They comprehended the views of the French school *quoad* biology, and these were far in advance of the British in 1829; moreover, they gave a direction to the feeling for the natural sciences in the ancient University. If the museum of St. Andrews was not large, the student had the neighbouring quarries, rocky coast, and hedgerows for helps to his geological and botanical researches, whilst zoological demonstrations could be had on the sea-beach and in the ocean's wave.

During the recess or summer months Goodsir showed no small liking for plants and animals, read Buffon and Goldsmith, watched the growth of tadpoles, scrutinised the contents of marine nets, traced the ropes and rigging of the small crafts in Anster harbour, and in various ways showed the intelligence, constancy, and methodical study that characterised him in after years. From his mother—a woman of artistic powers—he got lessons in drawing, and he

eventually imbibed a love of art almost as strong as his love of natural science, and this too at a very early age.

His self-education went along with his academical, and received every encouragement at home ; and, as his brother writes, "this self-education, which afterwards developed itself fully in his professional and scientific walk, proceeded in three directions :—1*st*, in observations of the works of nature and art ; 2*d*, in the acquisition of knowledge from books ; 3*d*, in an almost instinctive tendency to employ his admirable hands in observing what struck him, or in constructing various mechanical and other objects according to their true principles, as he had learned them, or latterly in experimenting or anatomising." A *camera lucida* excited his curiosity, and made him turn to the *Encyclopædia Britannica*, which ever afterwards became his reference on all matters of doubt pertaining to his youthful efforts. The work belonged to his grandfather, and had been well thumbed by a lad of the name of John Leslie of Largo. Its careful perusal probably helped to make that lad the Rumford medallist of the Royal Society in 1803 for his Researches on Heat, and, at a later date, the celebrated Edinburgh professor, now best known in history as Sir John Leslie the philosopher.

Though so favourably situated for the study of medicine and the natural sciences, John Goodsir seems to have had a greater desire for mechanics ; he used to say in after years that had his family given him free scope he would have turned his

abilities to engineering work or the construction of mechanical apparatus. With the aid of a school-fellow he got up a turning-lathe; he also studied the steam-engine, and made experiments in chemistry. In May 1829 he heard a lecture of Professor Christison's in Edinburgh, which gave fresh zest to his efforts in chemical manipulation and inquiries. His desire to work by himself created enemies among his school-fellows; and his younger brothers, excluded from the improvised laboratory, vented their anger in the same vernacular form as Dr. Cullen's famous "Can this be our Jock?"[*]—by calling from the outside, "Mathematical-Chemical Jock!" The young chemist had ample reward for his industry, and forgot all the taunts of his companions when Professor Syme, called to a patient of his father's at Anster, and seeing the lad John handling some *calculi*, asked him their nature, and being told correctly, bestowed no small amount of commendation on his chemical skill—a pleasant episode in his juvenile history that was never effaced from his mind.

Anstruther, like all sea-side places, afforded play to the playful, and much of an interesting nature to observing lads. Of the numerous belongings there

* Dr. John Brown, the assistant of the famous Cullen of Edinburgh, feeling himself aggrieved by the Professor's treatment, sought a Mastership in the High School of the city. Cullen heard of this, and vented his indignation by asking those who spoke of Brown's application "Can this be our Jock?" Brown took his revenge and wrote *Elementa medicinæ* hoping to crush Cullen's theory of physic; but "the Brunonian system," as Brown's views were termed, though favoured in Germany and Italy, gained small ground in Britain.

were "the smacks"—"Rob the Ranter" and "Maggie Lauder"—the boast of the port, as re-echoing the strains of "Anster Fair;" the fishermen with their nets and tackle on the beach creating in boys a curiosity to know the names and uses of the nets' contents, and that curiosity heightened by the superstitious stories told of the uncouth denizens of the deep. With fish and fun and "sailors' yarns," there were also abundant materials, and of the most interesting nature, for investigation; and who so likely to take advantage of them as the sons of Dr. Goodsir, to whom the unknown "oddities" were continually being offered for inspection and discrimination? Marine zoology was at the door of the Goodsirs, and love of the sea would increase the enthusiasm of the pursuit; for what life could be more charming than holding the helm, or "hauling in a sheet," while the light bark skimmed o'er the waves, unless the greater pleasure to John and Harry Goodsir of watching the exuberance of animal life that was free to roam over the wild sea's foam; or when that life, caught in the meshed trail, came to be cabin'd and confin'd, to see the motley group of entities, wanting the loves and affections that bind warmer natures, manifesting rapacity as their only law, and voracity as the sum and substance of life? What opportunities to lads bent on zoological inquiry and in the possession of brain, energy, and education! What glorious incentives to study in having the faculties of the mind, and all the senses, made partakers of the pleasure of

observation! Almost every haul in the waters of the Firth brought up organisms, fitful in action and Protæan in character;—the faceless, shapeless, round, angular, and stellate forms; the gelatinous, pulpy, passively transient; the finny, scaly, and gliding-surfaced; the shelly, cretaceous, or bristling-defiant, mingling with the more harmonising and attractive, showing their lines of beauty, and dots and streaks of colour, nature-anilined, gold or ruby;—all studies of the vast waters of

> The sea, the sea, the open sea,
> * * * * *
> And the whale it whistled, the porpoise rolled,
> And the dolphins bared their backs of gold.

CHAPTER II.

Edinburgh Studies and Dentistry—Anatomy his chief Pursuit—Dr Knox and other Teachers—Medical Societies—Friendship with Forbes—Gets a Surgical Diploma, and joins his Father in Practice—British Association, 1838.

Being well grounded in Latin and Euclid, and disposed to mechanics, chemistry, and natural history, John Goodsir seemed fitted for the professional walk of his family. Being desirous that John should, in the course of time, enjoy the privileges of a Fellowship of the Royal College of Surgeons in Edinburgh, his father, with a view to easy pecuniary terms, thought of apprenticing him to Mr. Liston or Mr. Syme. Meanwhile, his old friend Mr. Nasmyth, dentist, and also Fellow of his college, offered to take John as a pupil and without fees. This offer was gratefully accepted, and John was apprenticed for five years to Mr. Nasmyth, who, as a master, treated him kindly and considerately.

In November 1830, John matriculated in Edinburgh, and attended medical classes both within and without the University walls. His most absorbing course of lectures during the first session was Dr. Knox's, on descriptive anatomy, delivered in Old Surgeons' Hall. Though not engaged with forceps and scalpel in hand, he was daily in the rooms watching

the progress of dissections, and adding to his stores of osteology. In his second year practical anatomy so absorbed his attention that he wrote to his father asking his permission to become a surgeon, and not a graduate in medicine. No doubt he was influenced in part by his admiration of Knox, and a wish to avoid attendance on Monro, and possibly also with a view to economise his father's means. Immediately previous to Goodsir's student-days, the Edinburgh school of anatomy was supplied with *materiel*, got from the burial-grounds of the neighbourhood, or from England, even London itself. The men who robbed the graves of their contents were called "Resurrectionists," and vile rascals they were ; some of them, not content with nocturnal depredations, took to the heinous crime of sacrificing the living for the sake of the booty their cadaverous victim would yield. Fifteen or twenty guineas for an adult subject was a great temptation to the body-snatchers. Students of anatomy, till the act legalising the removal of the unclaimed dead came fairly into operation—and this was hardly the case in 1832—had to pay dearly for their opportunities of practical knowledge; thus Goodsir had £2 to pay for an upper extremity, and this he laboured at with a zeal that implied a determination to exact the pound's worth from the pounds of flesh. He wrote to his mother as follows—"I do not occupy much of my time in dissecting animals, as I am too much employed with human anatomy; but when I find a leisure hour in dissecting one, the information I acquire is so much

connected with the subjects discussed in other classes that it gives me a superiority over others, who only obtain at second hand what I acquire by actual inspection."

Young Goodsir was a thorough student, practical at work, thoughtful of the hour and the aim and passion of his life, so that the smallest effort in the way of common business matters disturbed him quite as much as an adverse vote in Parliament could affect the most gouty of premiers. The following quotation from one of his letters shows this :—"Everything connected with my studies goes on to my heart's desire, but my *bump of order* is confused when I have to settle anything connected with money matters, letters to be written, calls, etc." He had declared in a previous letter that he was not fit for the management of the most common concerns of life. His landlady's account of larder-furnishings for the week bothered him, and home commissions were no less troublesome.

After two years' experience of dentistry he got tired of the work, and longed to be free, for, as he argued, after so many hours of each day so spent, he could not possibly keep pace with other young men in the profession who had no such drawbacks. In 1833 he lost his temper *quoad* dentistry. The influenza raged as an epidemic in Edinburgh, and he had an attack; but tooth-pulling was vastly worse in Goodsir's eyes—almost a quotidian ague. He disliked the art from the beginning, not *per se*, but as a hindrance to the higher studies of medicine and surgery; and, as

he wrote, he wished to exercise his hands and his mind with other instruments, and with other subjects, than "smith's forges, brass furnaces, and sand-grinding stones." He was chagrined at seeing the dentist better paid than the surgeon, when the only diseases he had to treat were toothache and gum-boil, his only operation the extraction of teeth, and his whole pharmacopœia tincture of myrrh. Ill at ease on the matter, he sought to be free from his apprenticeship. Dentistry and domestic details stood between him and life's pleasurable enjoyment; the one a constant gum-boil that no tincture of myrrh could palliate, the other a halfpenny arithmetic beyond the aid of a ready-reckoner. Soaring above the mechanical agencies of a speciality like dentistry, his scientific aim became too impetuous to be restrained by any bonds; so Mr. Nasmyth very kindly cancelled his indentures before the expiry of the legal term. Goodsir's dislike stood in strange contrast to the progress he had made in an art for which his head and hands were so well equipped—an art that would have brought more money to his coffers than the most favoured following of the natural sciences. Mr. Nasmyth's confidence in his pupil's powers was such that he entrusted his large practice to him during the autumn of 1835, and with entire satisfaction. Whilst his master's *locum tenens*, Goodsir wrote to his father that Daniel O'Connell had been haranguing the Edinburgh worthies; and that, wanting a tooth extracted, sent for Mr. Nasmyth, in whose absence he went; that the "Great Agitator" made no demur to

his youthfulness, but opened his mouth as the operator entered the room, as if to say "Out with the rascal!" When Goodsir's forceps had relieved him of his posterior molar, the "Great Dan" had his joke at the loss of a wisdom tooth, and the "repeal" of their union.

Anatomy was Goodsir's hobby; he did not limit himself to the purely "descriptive," but tried to advance his knowledge of surgical and pathological anatomy. During 1832-3 he made plaster-of-Paris casts of his dissections, to the surprise of his fellow-students, who had never heard of such a way of rendering dissections permanent and instructive. After some experience, he tried to imitate the models of ulcers and other lesions in the College of Surgeons, done by Sir C. Bell, who stood unrivalled in the art, and believed he had discovered the secret from experiments of his own: it was painting with coloured burnt wax, or the encaustic method of the ancients. He took his plaster-of-Paris cast of the ulcer, and completed his work at the bedside of the patient, in the wards of the Royal Infirmary. In putting up preparations, in articulating skeletons, and in every mode by which individual specimens of the animal series could be illustrated, or morbid growths preserved, he showed surpassing care and neatness. His teachers availed themselves of his work; Knox giving him a pike to form a skeleton, and other teachers morbid specimens to preserve. He was studiously nice in his mode of operating, and learned to do everything for himself: he laid down a principle

worthy of being red-lettered in every dissecting-room, that a piece of true dissection ought to turn out an object of wonder and beauty. In his case, as his brother remarks, "his tools were deserved because he could use them; and, like a good workman, he took pride in his tools and cared for them."

In his third session he made a collection of morbid and healthy anatomy of the teeth for Mr. Nasmyth; and this work probably led Goodsir's attention to the development of the human tooth and the interesting changes connected therewith. About the same time, possibly later, a work of Carus's fell in his way, the perusal of which strongly impressed him with the importance of the study of developmental anatomy, and gave the first impetus to his researches in that direction. Goodsir could not fail to be noticed in the classes; he obtained attention from his fellow-students by his methodical demonstrations, his sketches, and casts; while his teachers early detected in him superior ability, and a growing love for learning in every professional walk. The recognition of Goodsir by Knox was agreeably shown by soliciting him to become one of the vice-presidents of the Anatomical and Physiological Society, of which Knox was president. It may be noted here that Goodsir joined the Royal Medical Society on November 8, 1833, probably for the advantage of the library, as he does not seem to have taken any part in Society business.

Mr. Goodsir owed a great deal to Dr. Knox, and

always spoke of him as his anatomical teacher and friend. In 1830 Knox was far above his compeers, and did more than any teacher, professorial or extramural, to revive the fame of the anatomical school of Edinburgh, that had been on the wane during the reign of Monro *tertius*. He was the successor of Dr. John Barclay, in 1825-6, and extended the reputation, so well founded, of that distinguished anatomist.* Knox won the admiration of John Goodsir, and of every intellectual student; for who could fail to be pleased with a lecturer so fluent in speech, so persuasive in style, and so generally impressive and eloquent? The plainest visaged man in Edinburgh, Knox was gay in dress, with embroidered purple vests, gold chains in profusion, and dandyism; moreover, he was a courtier in manners, a dramatist in action, and possessed of a rhetorical faculty that would have suited the Bema, the Forum, or the Tribune. He had a class of 504 pupils (session 1829 or 1830), the largest anatomical audience ever

* John Barclay was educated for the church, and, as a probationer, was for some weeks the *locum tenens* of the Rev. G. Baird of Bo'ness, afterwards Principal of the University of Edinburgh. Mr. Baird, wishing to ascertain how his parishioners liked Barclay, asked the opinion of a shrewd villager. "Gey weel, minister, gey weel," quoth Sandie; "but every body thought him daft." "Why, Sandie?" "O, for gude reasons, minister; Mr. Barclay was aye skinning puddocks" (frogs). This dissecting of frogs changed Barclay's thoughts, and he took to medicine, and became a man of mark in the anatomical school of Edinburgh. He bequeathed his fine comparative anatomy collection, and other preparations, to the Royal College of Surgeons. It used to be said that dogs avoided Barclay's path from an instinctive dread of his dissecting them. If disliked by the animalities, he was much esteemed by his contemporaries and friends. He rendered the medical school no small service.

known in Britain. A scholar and a man of great ability, he possessed a self-reliance that never failed him in the lecture-room, within the hall of his college, or the inner circle of the Royal Society. Anatomy lost its repulsive character to the student, looking at Knox's masterly attitudes—so effective, graceful, and inimitable—and listening to his graphic descriptions and narrative, in which the historical was blended with the figurative and sensational. Knox in his lecture-room carried all before him: his voice, now gentle as a zephyr, or evenly melodious, occasionly rose with characteristic force, to barb the cynical shaft, to heighten the historical figure, or to fan the professional ardour of his class. His wit was keen, flashing, and incisive, highly amusing to the listener, and oft withering to the object of his causticity. As a teacher inspiring youths with a love of biology, he had no rival, nor was he less grand in discomfiting the charlatanisms, the royal roads, and trade-following of physic. Pertinent in description, and ever rich in illustration and critical acumen, Knox revelled in variety of work, from the examination of a tissue to the broadest generalizations and occasionally became prophetic of types and homologues.* If his lectures did not fathom all,

* Whilst Dr. Knox and the writer (Nov. 1840) were arranging a series of humeri for lecture, a marked point of bone at the lower third of the inner surface of one of the specimens was observed, and, on further examination of the entire collection, other humeri presented more or less of a bony eminence, not, however, of such a character as to attract attention. After some thought, Knox said—"This is a rudimentary structure, Dr. Lonsdale, and rest assured you will some day find in man a *supra-condyloid foramen*

they were suggestive of more than all that had ever been proclaimed from British anatomical rostrums. His translations of Cloquet and Beclard, and his efforts to impress the English mind with the doctrines of Bichat and Geoffroy St. Hilaire, and his own marked tendency to morphology, helped much to create inquiry among his own pupils, and to promote the growth of a philosophic anatomy in Britain.

Under such a teacher as Knox, Goodsir's anatomical predilections had every chance of being strengthened, for session after session he heard lessons in comparative anatomy from a master of the art, who could harmonize the incongruous forms, typify the natural series, and with a lofty rhetoric clothe the dry bones with fibre and flesh ;—putting in force the springs of motion and all the varied manifestations of life. The museums, private and public, also presented to Goodsir's cognizance the chief zoological data of the Old and New Worlds—data marvellous of themselves, yet indicative of a mightier aggregate—data as varied as the pebbles of the sea-shore, of which but few examples could be fully determined, and those only by a Newton or a Cuviêr. If Knox was at home in descriptive and general anatomy, he was rich and rare upon the human

transmitting the brachial vessels and median nerve, as you see in the *carnivora*." This prophecy was verified within a few weeks in the practical rooms, and, of course, to Knox's great delight. On an adjacent table the carcase of a huge jaguar was lying, with its natural supra-condyloid foramen, with which to compare the human rarity. This jaguar, so wonderfully tamed by Mr. Carter, had been the great sensational fact in a large menagerie.—*Vide Ed. Med. and Surg. Journal*, July 1841.

cranium and the history of races; so that, in whatever direction the student aimed his course, Knox could be his guide, philosopher, and friend; and he was all these to John Goodsir.

Mr. William Fergusson and Dr. John Reid were Knox's demonstrators. The former looked at anatomy in relation to surgery, and to-day has his reward in being Sergeant-Surgeon to the Queen, and a member of the British baronetcy.

Few could fail to be struck with Reid's appearance, bucolic gait and manners, ruddy complexion, with long locks of black hair hanging over his neck and coat-collar, broad forehead and open countenance. Underneath an outer toga that Reid wore, rather shambles-like, in "The Rooms," was a man of large heart and large promise. Reid's *forte* was physiology, the teaching of which Goodsir fully appreciated, but his greater liking was for the fellowship and friendly counsel of the man himself. One early debt of gratitude he owed to Reid was a recommendation to Professor Alison, of the institutes of medicine, as the person best fitted to go through a series of dissections in comparative anatomy, which the professor wished to do at that time for his own information. Goodsir naturally felt the honourable distinction of being closeted with the academical physiologist for two hours, demonstrating to him the cuttle-fish. A pretty picture might have been conceived from this episode in the lives of both men; the philosophic Alison watching the operations of the Fife lad in his

dissection of the mollusc, the young naturalist modestly pointing out the parts of the anatomy and their uses; age and youth changing their respective positions in the field of teaching, yet pleasantly in concert exploring organisms for the elucidation of one of Nature's plans, by which to unravel the type of a larger series.

Mr. Syme was the surgical teacher and attached friend of Goodsir; and no one of the Edinburgh school has done more for its surgical fame than the present distinguished professor of clinical surgery. Adorning his position by numerous improvements in his art, as acknowledged throughout Europe, he has, in his forty years' experience as a lecturer, contributed largely to the surgical indoctrination of the British mind both at home and abroad. Acting as dresser, and often as assistant, to Mr. Syme, Goodsir enjoyed the best surgical education in Edinburgh. Nor did he overlook the great props of his medical building, and that of materia medica was far from the least. Professor Christison's lectures were a daily treat of admirable instruction, as thousands of graduates, distributed over the world, could readily testify. Goodsir never forgot the kindness of Dr. John Macintosh, a popular extramural lecturer on practice of physic, from whom he derived much excellent information.

If anatomy and surgery were the corner-stones of the Goodsir fabric, the ornamental column was natural history, then taught by Professor Robert Jameson, a disciple of Werner and a mineralogist of distinction. In his measured walk and fixed countenance, Jameson

betokened the man of gravity and precision, if not the abstract thinker. In society his manner was cool, reserved, and taciturn; but he was a man of his epoch, and ever zealous for the extension of his science. He belonged to the conservative school of natural history. Though agitated by the bold innovations of Berzelius, and the greater discoveries of Mitscherlich in his special walk of mineralogy, and oft refreshed by the advancing tide of biology, upon which new sciences like palæontology were being wafted, he showed in his latter years a less responsive call to the tendencies of the age, now looking beyond the museum era of stuffed birds and the colouring of tattooed New Zealanders. John Goodsir and his friends Edward Forbes and Hugh Falconer, were among the chief of Jameson's pupils in the fourth decade of the century; all acknowledged their master's worth, and helped to extend his fame, and all, like himself, have paid their last tribute to nature. Jameson in his lecture-room can never be forgotten. Appearing as if enveloped in his professor's gown, his head of black hair was brushed stiffly upward, and gave bold relief to his brow; his sallow, strong-lined physiognomy, indicative of the wisdom of the sage and the appeal of the preacher; his head thrown back and fixed; his slow, precise, and oracular utterances, each sentence of import being accompanied by an emphatic throwing of the folds of his gown across his left breast were all grand *adjuvantia* to the occupant of a platform; and assuredly no man looked more like a philosopher than Jameson.

When Goodsir studied chemistry in 1831, the teaching of the science was more theoretical than practical. Dr. Thomas Hope, known as "Strontian Hope" for his one discovery, was not an enthusiastic teacher, and not likely to fascinate the young idea with the grand problems awaiting solution in the science. He was dry, didactic, yet methodical and accurate in his experiments, and a gentleman of the old type, and essentially academical. Dr. Graham, the professor of botany, whose lectures were attended by Goodsir, lived and died in the Linnæan faith, despite Jussieu and Decandolle, and held by a pocket-lens as if the microscopic observations of Dr. Robert Brown had never been made. Without a natural-history inheritance, Goodsir's botanical knowledge would have remained latent as far as teaching affected its genesis.

Goodsir's character kept him from a promiscuous acquaintanceship. His brother observes—"When he saw or felt there was no affinity, he quietly but resolutely kept within himself. In addition to this, the remains of what was an innate and sometimes painful sensitiveness and modesty acted on him powerfully, often disadvantageously, through life. Nevertheless he always enjoyed the real good of having a quite sufficient circle of friendly acquaintance, as well as an inner circle of tried friends, whom he valued highly, loved sincerely, and delighted in as companions." His closest and most important friendship was with Edward Forbes of the Isle of Man. They met for the

first time in Knox's rooms, and instinctively drew towards each other with the confidence of travellers going the same road, and formed a friendship that became firm, cordial, and permanent. Goodsir gave Forbes his first lesson in comparative anatomy by showing him how to dissect a snail of the genus *Clausilia*, found on Arthur's Seat. Forbes benefited greatly by his friend's hints, and took earnestly to malacology; and in after years became an authority in the natural history of the mollusca. The two lads, Fife and Manx, being of tall stature and characteristically visaged, though of different type, were the most conspicuous members of the anatomical class: *gemini* in their evolutions and craving search for the lower organisms, they were looked upon as a double star rising above the horizon of their compeers. Mr. Joseph Goodsir says of them—"Their ages differing only by a year, their mental and moral constitution, as also their intellectual and æsthetic tastes, fitted to work in harmony, even by the striking contrasts they presented—their very physical constitution, both being tall, lithe and powerful men in their respective fashions—by all these things they were formed to be companions and collaborateurs."

Mr. Forbes persuaded Goodsir to accompany him to a meeting of the "Royal Physical Society," as a paper was to be read on the chameleon. The theory of the action of the tongue in the chameleon, as given by the essayist, Forbes knew from Goodsir's dissections to be incorrect; so, without asking his bashful friend's

permission, which he well knew he would not obtain, begged the favour of the society to call upon a stranger then present for his opinions on the paper that had just been read. Goodsir was taken aback by this appeal, and could not help himself. So he rose for the first time in public arena, and pointed out the anatomy and true uses of the structures in the chameleon, and satisfied the author of the paper, and the society of his thorough knowledge of this oft-questioned and poetically-painted animal. This pleasant public initiative of Goodsir was taken advantage of by Forbes and Reid, who, aided by J. H. Bennett, now professor of the institutes of medicine—a friend who knew Goodsir's strength of intellect to be associated with a severe modesty—persuaded him to read an account of the snail, which he had drawn up, to the Anatomical and Physiological Society.* This paper, so novel and elaborate and highly illustrated, surprised and delighted his audience. It is characteristic of Goodsir, that this, his earliest scientific communication, was only drawn forth by repeated solicitations of his friends.

When anatomy, physic, and natural history—each and all in succession at nights—had satisfied his powers of hard thought, he took to Milton and the poets, Coleridge and other English writers of eminence, amongst whom Herschel ranked high. He

* This essay is not forthcoming. It has been supposed that he read it to the "Royal Physical;" but the evidence is largely in favour of the society mentioned in the text.

also took interest in the theological and other studies of his brother Joseph, who was preparing to enter the church, and there he indicated his true character—the early manifestation of his grandfather's inheritance, theological as well as medical—by insisting unweariedly that his brother was neglecting what ought to be his main study, that of the Bible itself. His brother's experience to this day testifies to the wisdom of that warning.

In 1835 he became a licentiate of the Royal College of Surgeons, Edinburgh. All he had to say on his becoming a surgeon was—"The examination lasted half-an-hour, and was most satisfactory and pleasant to me, I do assure you." After aiding Mr. Nasmyth, he joined his father in practice at Anstruther. His love of anatomy prompted him to carry to Anstruther an entire "subject" for dissection, a most hazardous undertaking, by coach and steamboat. He turned all his dissections to good account by casts; and those he made of the perineum (1837) are now in the Anatomical Museum of the University. The Rev. Mr. Goodsir says—"John was endowed with the natural gifts of strongly-marked intellectual and artistic powers, and with the unwearied assiduity, or rather with that capacity of deriving pleasure from the exercise of his powers, which is as necessary as the possession of power itself for the accomplishment of true and valuable work." Goodsir became an excellent medical practitioner, and occasionally had the opportunity of proving his dexterity in operative surgery. He was

the third "Doctor John," and considered the highest taught of the surgical family. Cases like Lady ———, where consulting physicians failed and he succeeded, rang through Fife, and to his great benefit. He had a thoroughly practical mind—a great desideratum in medicine; but it need hardly be said that Anstruther offered no field for a man of his capacity. There were bread-and-butter earnings, and home amenities—a scanty pabulum, however, to a man of craving scientific appetite. His inquiries into the teeth, and his general and microscopic examination of the Invertebrata, kept him mentally alive; indeed, his scientific habit had become known, as Sir J. G. Dalyell, in 1838, addressed him as a fellow-naturalist, and asked him about the Holothuriæ, and the mode of dredging practised on the Fife coast. In the same year he completed his investigations into the development of the teeth, and was pressed—for it was no easy matter to persuade him—to communicate the results of his inquiry "On the Origin and Development of the Pulps and Sacs of the Human Teeth," to the British Association for the Advancement of Science.

Attending the British Association in 1838 was a great effort for Goodsir to make; but when there, he had his reward in enjoying high rank among the original contributors, and in being appreciated by his seniors in science and the *savans* of Europe. In writing his father on the hearty reception he had met with, he said—"I need not tell you the kind of

pleasure one feels in such a sudden change from a remote situation, where no one is able to understand or sympathize with you in your pursuits, to a place which contains within itself all the talent and science in Europe, and where every one is eager to acquire and communicate knowledge;" and in reference to his paper—"that his facts were new to science, and that he had completely set at rest the great questions in this department of anatomy, so far as human structure was concerned." Thus he was satisfied with his first public effort, and encouraged to extend his labours. It was a great step for a village doctor to make, so that Dr. George Johnston, the naturalist, might well sympathize with any and every effort of a provincial practitioner to help on science, and to rescue men like himself and Goodsir from the sort of superciliousness with which metropolitans were apt to regard them. Scotland has produced other examples as marked as Goodsir and Johnston of country doctors extending the boundary of both literature and science; and Dr. Francis Adams of Banchory, the Oriental scholar and translator of *Paulus Ægineta*, and Dr. Moir (Delta) of Musselburgh, may be cited as instances.

CHAPTER III.

Memoirs on the Teeth—Jameson's Kindness—Model Museum—Crania from Fife Barrows—Fossil Fishes—Dredging with Forbes—Natural History and other Papers read to the Societies of St Andrews and Cupar.

THIS essay, "On the Origin and Development of the Pulps and Sacs of the Human Teeth," is an excellent and characteristic piece of Goodsir work, and a carefully-studied inquiry into one of nature's peculiar operations in the human economy. Though hundreds of volumes bore more or less upon the subject, Goodsir was alive to the fact that much remained to be done, and his experience in dentistry was a fitting introduction to the work. The principles of his memoir on the teeth existed hypothetically in Goodsir's mind as early as the year 1834, when he made the preparations for Mr. Nasmyth, and only remained to be fully verified by the investigations he was enabled to pursue after entering medical practice. He examined the human dental arches of different ages, from the embryo in its sixth week through every month of fœtal and infantile life upwards to adolescence, and his observations afford abundant evidence of great research and originality.

He divided dentition into three stages:—1*st*, the Follicular; 2*d*, the Saccular; and 3*d*, the Eruptive. He also indicated a stage previous to the Follicular,

during which the follicle or sac does not exist, and the future pulp is a simple *papilla* on the free surface of the gastro-intestinal mucous membrane; this papillary stage being of short duration, was included under the follicular. About the sixth week of embryonic life he found a depression or groove in the form of a horse-shoe along the edge of the jaw in the mucous membrane of the gum, and this he named the *primitive dental groove,* as the germs of the teeth first appear in it. By the thirteenth week a series of ten papillæ arose in succession in each jaw, constituting the germs or rudimentary pulps of the milk-teeth, and which he viewed as processes of the mucous membrane itself. Each papilla adhered by its base to the fundus of the groove, whilst its apex, up to the eleventh or twelfth week, presented itself at, or protruded from, the mouth of its follicle. The upper jaw was earlier than the lower one in respect to this stage.

The follicles appeared to Goodsir as mere duplicatures of the membrane of the groove, or the general gastro-intestinal mucous membrane passing across and between the papillæ. Each of the individual follicles, with its papilla, vascular branches, and nervous twig, exactly resembled a large hair-bulb, with its nerve and vessels exposed after the hair has been extracted.* As

* This opinion receives confirmation now that the teeth and the hairs rank as homologous organs. Professor Huxley viewed them either as both *enderonic,* or both *ecderonic.* The "basement membrane" being found an imperfect test, Huxley, guided by the question of growth, considers the hair, the teeth, the scales of fish, and probably the "dermal plates" of reptiles as ecderonic organs.—*Supplement to Cyclopædia of Anatomy and Physiology,* p. 476.

the papillæ grew, they showed peculiarities of form corresponding with that of the crowns of the future teeth. After a time the lips of the dental groove and small laminæ or opercula of membrane developed from the sides of each follicle begin to cohere from behind forwards, obliterating the groove and converting the follicles into closed sacs, and then commences the saccular stage of the milk-teeth.

As these stages proceeded, Goodsir observed several changes in the growth of the human tooth resembling what is met with in the lower animals, and felt disposed to view the opercula of the human tooth follicle as rudimentary organs, which attain their utmost development in the sacs of the elephantoid, ruminant, and other compound teeth, under the form of depending folds for the secretion of the intersecting enamel and cement-plates. As illustrative of the law of progressive development, he cited the human molar tooth-pulp—first rounded as in certain fishes; then conical as in other fishes and reptiles; then conical and flattened transversely as in the carnivora; and finally, by the equalisation of the primary and secondary tubercles assuming the shape of the molars in the quadrumanous animals and man.

When the *primitive dental groove* contained ten appillæ in as many follicles, and became situated on a higher level than at first, he denominated it the *secondary dental groove.* This groove affords a provision for the production of all the permanent teeth, with the exception of the first anterior molars: the preparation

is made by little depressions in the form of a crescent upon the inside of the mouth of each of the milk-follicles. These depressions Goodsir called "cavities of reserve," furnishing delicate mucous membrane for the future formation of the pulps and sacs of the ten anterior permanent teeth—incisor, canine, and bicuspid. The sacs in which the six posterior (superadded) permanent teeth, or the three permanent molars on each side, which arise from successive extensions of the dental groove carried backwards in the jaw posterior to the milk-teeth are developed, Goodsir named "posterior cavities of reserve," the wisdom tooth being the final development.

Goodsir looked upon his follicular stage, from the first appearance of the dental groove and papillæ, till the latter became completely hid by the closure of the mouths of their follicles, and of the groove itself, as a hitherto unknown stage of dentition. He was the first to point out the peculiar development and character of the anterior permanent molar—the most remarkable tooth in man, as it forms a transition between the milk and permanent teeth: if considered anatomically, it is decidedly a milk-tooth; if physiologically, a permanent one. No observer had noticed the peculiarity of the anterior molars that Goodsir established; he did not fail to mark the practical bearing of the growth with the decay of the said teeth.

The careful investigation of the whole process of dentition in man, and the clear illustrations given of the text, fully justified Goodsir in the conclusions he drew from his researches. The milk or deciduous teeth

used to be considered as the parents of the permanent teeth; whereas Goodsir showed that they are both laid down separately and independently of each other. The profession fully agree as to the value of Goodsir's discovery. Mr. Flower, one of the latest authorities on this subject, appropriately says—"It should be remembered that instead of there being any such relation between the permanent and milk-teeth as that expressed by the terms 'progeny' and 'parent' sometimes applied to them, they are both formed side by side from independent portions of the *primitive dental groove,* and may rather be compared to twin brothers; one of which, destined for early functional activity, proceeds rapidly in its development, while the other makes little progress until the time approaches when it is called upon to take the place of its more precocious *locum tenens.*"—(*Trans. Roy. Soc. London,* 1867.)

From Vesalius to our own times, the milk-teeth used to be looked upon as the germs of the permanent ones. Eustachius was almost the exceptional instance to the current opinion; he believed that the germs of both sets of teeth existed in the jaw of the embryo. Duverney and Herissant had a glimpse of the nature of the follicles and their relation to the gums, and Jourdain gave a minute description of the follicle from its first appearance in the fœtal jaw till the period of birth. Blandin considered the teeth as productions of the mucous membrane analogous to the nails and hair, and seems to have approximated more closely to the true conception of the dental follicle than any of his

predecessors. Serres, the octogenarian, who died in January last, and the successor of M. De Blainville, like Goodsir in being the son of a country practitioner, and still more like him in character and work, advanced our knowledge of the embryonic condition of the dental apparatus in his able treatise on the anatomy and physiology of the teeth. He described the germs of the two sets of teeth, the membranous folds and partitions, and the relative position of the anterior molar to the canine, and did much to advance our knowledge *quoad* dentition. Hunter, Baron Cuvier, and his son Frederick, Purkinje, Müller, Retzius, Bell, Blake, Owen, and Nasmyth and others laboured at different departments of odontology, confirming in part the researches of Malpighi and Leeuwenhoek, and contributing fresh facts to the accumulating stores; but none of these eminent men gave that attention to the embryonic conditions of the teeth that Goodsir bestowed; and no one succeeded as he did in furnishing a consecutive and complete account of the whole process of human dentition. His observations were systematically recorded, and in the most precise way, and this is a great desideratum in anatomical science.

When Goodsir read his paper to the British Association, he believed that most of his facts were new to science, and this was the prevailing opinion at the meeting. In a postscript note (vol. ii. p. 51), Goodsir explains how he became aware of Professor Arnold's discovery of the milk-tooth sacs formed by a duplicature of the mucous membrane of the mouth, published

in a Salzburg periodical in 1831, and adduced by Valentin in his work on Development. That Goodsir's researches were made independently, no one doubts, and the comparatively isolated observation of Arnold in no wise detracts from the larger and more successful investigations of the Edinburgh student. Arnold's views rested on so limited a basis that his own countrymen had failed to recognise their application. Raschkow and Purkinje differed from Arnold's opinions soon after these were made known in Germany, as to the dental follicles taking their origin from the mucous membrane of the mouth. Goodsir's observations were the most circumstantial and complete ever put before the profession. To claim perfection for Goodsir's work would be unworthy of the physiologist, as his views on the primordial condition of the dental germs may possibly admit of a slight modification; indeed, objections have been raised by Continental anatomists on this special ground. After twenty years of general acknowledgment of Goodsir's correctness, the superficial and open condition of the dental sacs, and the papillary commencement of the pulps, were questioned by Guillot in the *Annales des Sciences Naturelles* for 1859, and in the following year by Messieurs Robin and Magitot in the *Journal de la Physiologie.* These gentlemen threw some doubts on the mode of Goodsir's dissecting, and attributed some of the free surfaces he had described to the use of the needle or brush upon mucous membrane. Kölliker subsequently defended Goodsir's main points, not, however, without an ad-

mission that in some of his specimens the epithelium had been abraded, rendering the follicles and papillæ somewhat unnaturally open to the surface. Goodsir used to say that Monsieur Robin, who objected to the open follicles, did not look at the structures (embryonic) sufficiently early, and therefore he only saw the follicles when they were really closed sacs. Satisfied with the general accuracy of his own observations, and seeing nothing to shake his faith in them, Goodsir took no steps to put himself right with his French contemporaries. The writer of these pages has always looked upon Goodsir's Memoir on the Teeth, his first effort in developmental anatomy, as his best work, and is happy to find his humble opinion supported by the best authorities in Britain—Owen, Sharpey, Huxley, and others. The minute exploration of the anatomy, the historical sequence and application of the data obtained to both physiology and pathology, give a character and finish to Goodsir's researches, which no special work or parts of volumed history on the subject had ever furnished.

In the following year, 1839, he read a paper to the British Association "On the Follicular Stage of Dentition in the Ruminants; with some remarks on that process in the other orders of Mammalia," and announced the fact, that at an early period of embryonic life, the cow and sheep possess the germs of canine and superior incisive teeth, the former existing as developed organs in two or three genera only of ruminants, the latter being found in the aberrant family of camels,

which showed how general the law of unity of type is within certain limits. He drew a distinction between those permanent teeth developed from the primitive, and those developed from the secondary groove.

Being requested to publish his essay on the teeth in the *Edinburgh Medical and Surgical Journal*, he visited Edinburgh to arrange the engravings, when Professor Jameson sought an introduction to him through Mr. Nasmyth, and showed him great kindness, offering him the loan of one of Ehrenberg's famous microscopes, the discoveries made with which had startled Europe, and soliciting his company to look over the Natural History Museum. Fresh from the honours of the British Association, and now seated by the side of the Wernerian philosopher, implied that the Goodsir star was in the ascendant. The joint survey and talk about the museum had a meaning that Goodsir did not fail to interpret; indeed, both professor and practitioner seemed mutually pleased with each other, and from that October morning continued in happy alliance on the highway of science till the severance of the life-link of the aged professor. Though soon back to Anstruther and the drudgery of physic, Goodsir had resolved to look for a broader platform than "the Kingdom of Fife." Not that Fife was commercially slow or mentally stagnant, for the University of St. Andrews had strong genetic forces in Sir D. Brewster and others of scholarly aims, many of whom had been induced by other gales than fortune to set up their Penates in that retired historic nook—*sylvestrem tenui*

musam meditari avenâ. Moreover, St. Andrews had its "Literary and Philosophical Society;" and Cupar, the county-town of Fife, its "Literary and Antiquarian Society," both of which were flourishing, and claimed Goodsir as member.

In 1837 he began a natural-history museum alongside of his strictly anatomical and pathological. He had been gathering from the second year of his medical studies, and now wished to establish a collection worthy of the name and his own curatorship; and for this purpose explored the quarries of the neighbourhood and dredged the sea-depths towards the Isle of May. He had capital hands, and showed dexterity and neatness in all his work, and specially in preserving the skeletons and skins of fishes. So busy was he in this direction that his friends concluded he was bent on ichthyology proper. It cannot be said that he made great progress in geology, though a future page will show that he had a *penchant* in that direction. Owing to its arrangements, classification, and display, his museum was talked of as a model one, and attracted many visitors—even young men of science from Edinburgh. He presented his fossil fishes, supposed to be gems in rarity and character, to the Literary and Philosophical Society of St. Andrews. It was a source of regret in after years that he had not retained this nucleus of a collection in his own hands, as in the course of time its extension would have been greatly promoted, and especially after his rise to the anatomical professorship.

The opening of a barrow at Kingsmuir (Fife) in 1839, and the presentation of the skulls found in it to one of the meetings of the Cupar society, afforded Goodsir a fine chance of discussing the character of these exhumed relics of the far past. Whilst betokening a familiarity with anthropology that ensured the society's attention, he inferred, from the state of the teeth in the respective jaws, the nature of the food eaten by these early Fife settlers, be they Danes or ancient Caledonians. Various opinions, historical and ethnological, had been expressed by lay as well as medical members of the society regarding the crania before them, but no one hazarded a conjecture as to the liabilities, or flesh-and-blood conditions of the individual possessors during life. Nothing, however, escaped Goodsir's eye and discrimination. Having examined the pericranial surfaces, he pointed out the existence of morbid lesions dependent on a special *virus*, which had left so marked an impress on the bones that a thousand years had in no wise effaced or obscured its real character. Having gratified the society by the preciseness and originality of his views, he now surprised them by showing syphilitic nodes, as manifest as any modern instance, on one of the crania. Had the society been aware that in 1497, about four years after the return of Columbus from his first voyage to Hispaniola, the first Scottish edicts were issued against the *new* distemper, or "grand gore," "pockis," or "French infirmitez," the contents of the Kingsmuir barrow with its syphilitic member would

have been looked upon with still greater curiosity and attention. "Old Aberdeen," seeking purity of morals, and trying to wash her citizens clean of the "pockis," "French infirmitez," and other perilous stuff, by burgh edicts and excommunications, little dreamt that she was contending with an old enemy in the land—Satanic if not Spanish. Whether the "distemper" was old or new, Goodsir's diagnosis proved his surgical acumen, and showed how keenly alive he was to the science of medicine in all its aspects. To-day a rage for the exploration of barrows and the fingering of crania exists in Britain, but instead of having guides of the Goodsir stamp, divinity talkers, and credulous connoisseurs—men without anatomical knowledge or a comprehension of the difficulties attending anthropological pursuits—fearlessly "rush in where angels fear to tread." *Quousque tandem?* The exploring of barrows led David Page (now LL.D. and the distinguished President of the Geological Society of Edinburgh) and others to excavate the burial-ground of the ancient Abbey of St. Leonards at St. Andrews, where they discovered a cranium of one of the "Royal Stuarts." "The divinity that doth hedge about a king" did not protect this cranium from Goodsir's manipulation and mouldings. Others quarried for the treasures; Goodsir described them. The desecration of the supposed tombs of the Scottish kings got noised abroad, and gave rise to official remonstrance and interdict.

Mr. Goodsir read a variety of essays on Natural history to the society at St. Andrews, and at the re-

quest of its president, Sir D. Brewster, furnished a paper on *Cilia*. If he commenced with Leeuwenhoek's "*Continuatio Arcanorum Naturæ*," and traced the history of his subject down to the discoveries of Sharpey and Grant, supplementing them with his own work and illustrations, he could not fail to please and deeply interest a body of men who lived on the shores of a bay rich in ciliated organisms.

On November 30, 1838, Goodsir described certain fossil fishes from the limestone and slates of Corn-ceres quarry near to Anstruther. He stated that in addition to teeth of the *Megalichthys* and spiral *Coprolites*, he had found a number of entire specimens and detached scales of fishes referable to the *Lepidoides* of the *Ganoid* order of Agassiz; these latter specimens contained five species referable to two genera—one of these genera was closely allied to *Palæoniscus*, but differed from it in wanting the scaling or false rays along the anterior rays of the anal and dorsal fins, and on the upper and lower rays of the caudal, and also in the anal and dorsal fins being almost opposite to one another near the tail, as in *Dipterus*. To this genus Goodsir gave the provisional name *Catopterus*, at one time applied by Agassiz to the *Dipterus* of Sedgwick and Murchison, but afterwards rejected by himself; he considered three of the quarry specimens to belong to it. The second genus he viewed as intermediate between *Amblypterus* and *Eurynotus*, approaching the former in the form of the body, and the latter in the character of the dorsal fin, and differing

from both in the small size and acuminated shape of the anal and ventral fins, and in the extraordinary development of the caudal, the vertebrated portion of which rose almost perpendicularly to one-third the length of the animal. From the sail-like appearance of the dorsal and caudal fins, Goodsir proposed for the genus the provisional name *Istiopterus*. Two of the five species belonged to this genus. These fishes were all highly heterocercal, and in none of them was there any trace of the pectoral fins.

At a subsequent meeting he presented another fossil fish, also new, from the Cornceres quarry, which, in general appearance, approached the genus *Amblypterus*, but differed from it in the fins being triangular instead of quadrilateral, and resembling more the provisional genus *Istiopterus*, which he had previously proposed. All the ichthyolites from the Cornceres quarry were referable to the *Ganoid* order of Agassiz. The coprolites and detached teeth he considered indications of the former existence of a fish belonging to the *Sauroid* family of the Ganoid order. All the other fossils he showed were referable to the Lepidoid family; and these, nine in number, he described particularly. His frequent visits to Cornceres, and his apt observations of the fossilised forms found there, led many of his friends to suppose that he was now aiming at palæontology, his initiative in that direction of study offering high promise.

At another meeting he submitted specimens of two species *Beroë*, discovered by his friend Edward Forbes,

in company with Harry Goodsir, on the east sands of St. Andrews Bay. One was the *Beroë pileus* that had been imperfectly described by Grant in the *Zoological Transactions* of 1831 ; the other was new, and afterwards described by Forbes to the Royal Society of Edinburgh. Goodsir entered fully into the anatomy of these animals, particularly the Cilia, exhibiting drawings on a large scale of those interesting organs discovered by Sharpey, Purkinje, and Valentin.

To the "Cupar Literary and Antiquarian Society," in November 1838, Mr. Goodsir submitted a list of animals collected, preserved and catalogued by his brother Harry, that had been drawn up from living individuals gathered upon a surface of land and sea stretching one mile round Anstruther. The collection of a set of documents—zoological, botanical, meteorological, and antiquarian—Mr. Goodsir considered to be peculiarly the duty of a county philosophical association, and more consistent with the spirit of its constitution and the situation of its individual members, than any other kind of scientific labour.

In the spring of 1839, Mr. Goodsir read a paper to the St. Andrews Literary and Philosophical Society on certain peculiarities in the eye of the *Cephalopodous Molluscs*, basing his observations on the cuttle-fish. The first peculiarity, or exposed condition of the lens, considered so anomalous by biologists, he held to have been common at a former period of animal existence, with *nautili, ammonites, baculites,* etc. He looked to the embryonic life of vertebrate animals for an

explanation of the exposed lens of the cephalopod; he controverted Owen's opinion as to the eye of the animal possessing a perforated cornea and an aqueous chamber, and held by Cuvier's description of the organs. In reference to the second peculiarity, or the glandular body or mass, which Owen and Cuvier had viewed as a cushion to guard the optic ganglia from pressure, Mr. Goodsir considered it an organ which had already performed its functions in the embryo, and analogous to the choroid gland of fishes.

In June 1839, Goodsir and Forbes made an excursion to Shetland and Orkney, where they spent a fortnight in dredging. They were not so successful in their search for air-breathing gasteropods as in other directions, wherein they discovered new animals, and had the opportunity of supplementing the descriptions given by naturalists of some of the rarer species belonging to each locality. The results of this dredging expedition were laid before the Fife societies, and afterwards communicated to the British Association. Amongst the numerous specimens they obtained was a zoophyte, the largest known form of its tribe, about four inches long, and with a stem half-an-inch in diameter. They obtained it in considerable numbers on a sandy bottom, in about 10 fathoms of water, at Stromness, Orkney, and supposing it to be an undescribed form, proposed to give it the name *Ellisia flos maris;* but, to their disappointment, found that it had been discovered a short time previously by the Norwegian naturalist Sars, and named *Cory-*

morpha nutans. Their joint papers, read before the Fife societies, embraced the ciliograde animals found in the Orkneys, St. Andrews Bay, the Isle of Man, and Ballycastle Bay in Ireland. They also gave a systematic account of these *Ciliograda* to the British Association meeting the same year (1839), and described a new species of *Alcinoë*, which they had found in Kirkwall Bay, Orkney, by the name of *Alcinoë rotunda*, with the following characters:—Ovate, rounded, crystalline; tentacula rounded at their extremities; natatory lobes forming half the animal.

Goodsir's own and joint contributions with Forbes were the most frequent made to the Literary and Philosophical Society, so that St. Andrews had a fair chance of being *au courant* with the progress of science, and of knowing the men whose aspirations might be directed to the approaching vacancies in their ancient University. These Fife societies were favoured in a high degree. With Sir D. Brewster as president of the one, the Goodsirs and Forbes as anatomists and naturalists, David Page as geologist, Playfair, Adamson, Buist, and others as members, the Cupar and St. Andrews meetings almost rivalled the scientific societies of Edinburgh in the variety and originality of the papers introduced for consideration. Goodsir entered into the historical phases of his work, and showed familiarity with the labours of Cuvier, Audouin, Milne Edwards, Müller, and Agassiz abroad; and of Owen, Fleming, and Sharpey,

and other British authorities. Above all, he showed a painstaking research and originality of purpose. Sir D. Brewster used to speak of him as a man of superior culture, and one of the most rising men in science.

With the growing feeling that manifested itself at this period in various parts of the country in favour of popular lectures, the "Men of Fife" joined very heartily. Forbes gave a short course on natural history. Page and Adamson treated their special subjects, and Goodsir lent a helping hand, though it cannot be said that popular lecturing was much in his line. He lectured at Cupar on "The Conditions of Health;" and it is believed that he gave addresses on more strictly physiological subjects at St. Andrews, but the titles of his lectures cannot be correctly ascertained.

As evidence of his mind not being exclusively devoted to natural history proper, Goodsir read, on 3d February 1840, a paper to the St. Andrews Literary and Philosophical Society "On the Cephalic Termination of the Sympathetic Nerve," a title of itself to show that he was prepared to battle against Cruveilhier's opinions. Goodsir viewed the ganglia forming the linear series along the vertebral column as *centric;* those scattered through the system or viscera, the *excentric* ganglia of the sympathetic. He had no difficulty in showing the relation of the sympathetic with the cyclo-vertebral elements of the spinal column and the intestinal tube; but in proving a similar relation of the nerve to the cyclo-vertebral elements of the cranium and the

cephalic extremity of the said intestinal tube, he had to assume the vomer to be the anterior element of the cyclo-vertebral system in man. In maintaining this opinion he had the support of Carus and G. St. Hilaire's observations on the vomer in mammal embryology, and the higher interpretation of the same bone or laminated bar in the cranial structure of fishes and reptiles. Looking upon the basilar portion of the occipital, the body of the sphenoid, the vomer, and the median intermaxillary bones as cyclo-vertebral elements of the cranium, and these bones in close connection with the upper part of the intestinal tube, he inferred that in the immediate neighbourhood of these combined systems (vertebral and cephalic), the linear series of the ganglia constituting the cephalic portion of the sympathetic should be found. He fixed upon an azygos ganglion—the naso-palatine as the *anterior*,* and the ganglion impar as the *posterior* termination of the linear series of the vertebral ganglia. The otic, ophthalmic, and sub-maxillary ganglia were ranked by him with the cardiac and semilunar, as terminating in their proper organs, and not linear but *excentric* ganglia. He showed the analogy of this view of the human sympathetic nerve to the double gangliated row and terminal azygous ganglia which constitute

* Fontana, Hirzel, and Arnold believed that they traced filaments of nerves from the cavernous plexus to the pituitary body; if so, this body would be more entitled than the naso-palatine ganglion to hold a cerebral relation to the sympathetic system that the ganglion impar or coccygeal does to the spinal portion. Bock, Weber, and others, have not confirmed the views of Arnold.

the entire nervous system of the diplo-neurose sub-kingdom. This essay, resting a good deal on the osteogenesis of the human cranium, showed a large acquaintance with the German and French schools of medicine, and was probably the first marked indication of his study of the higher anatomy of Goethe, ably extended by Geoffroy St. Hilaire, and the subject of much comment and interpretation by Knox.

CHAPTER IV.

Habits of Animals—The Brotherhood of Friends of Truth—Goodsir returns to Edinburgh—The rising Men of the Medical School—Reid, Simpson, Barry, etc.—Goodsir's Appearance and General Character—His co-operation with Edward Forbes.

The habits of animals, from the polype to the ape, were a special delight of Goodsir's. A golden eagle was obtained from the Orkneys, and suitably caged at Anstruther in 1838. It was a sight to watch this noble bird kill its prey; as dead meat or carrion failed to preserve the beauty and grandeur of its plumage, the villagers were pleased to bring live animals for the purpose of seeing the eagle fed. Goodsir used to describe what took place when a cat was thrown into the eagle's cage: the fiercest feline was at once cowed; the eagle, perched in regal dignity, first cast a glance at its prey, then suddenly pounced upon the cat, striking the back with the talons of one foot, and paralysing the body below the stroke, and as the head of the feline was raised, it was at once enclosed within the talons of the other foot and crushed in a similar fashion, causing immediate death. Homer's description would well apply—

> . . . . ἀλλά τ' ἐπ' αὐτῷ
> ἔσσυτο, καί τέ μιν ὦκα λαβὼν ἐξείλετο θυμόν.
>
> *Iliad*, xvii. 677-8.

With the mastery of his victim came forth the display of his own excited nature, in the elevated head, the feathers of the neck stiff and erect, the wings flickering and spread to make the victory complete; then the epigastric section by its beak with quick despatch of thoracic contents, the disembowelling and carrying the strings of the intestines to its mouth with a rapidity worthy of the hungry Neapolitan swallowing maccaroni, and finally tearing off the muscular parts and leaving but skin and skeleton as vestiges of the feast. What a study of animal life within the Anstruther cage! The eagle in royal ease, the cat appalled, the descent from the perch, the clutch and death-stroke; the nobility of triumph evidenced in eyes of light, coloured radiance, and high feather; the evisceration, the feasting amidst hot blood, and the steamy vapours of vitality and quivering muscles mocking life in death, —constituted a picture as generic as it was grandly exciting and picturesque to behold. The eagle's love for things of the flesh would have caused the death of a child incautiously brought by its mother too near the cage, the wooden paling of which gave way under the impetuous dash of the ravenous bird, had not Harry Goodsir come to the rescue.

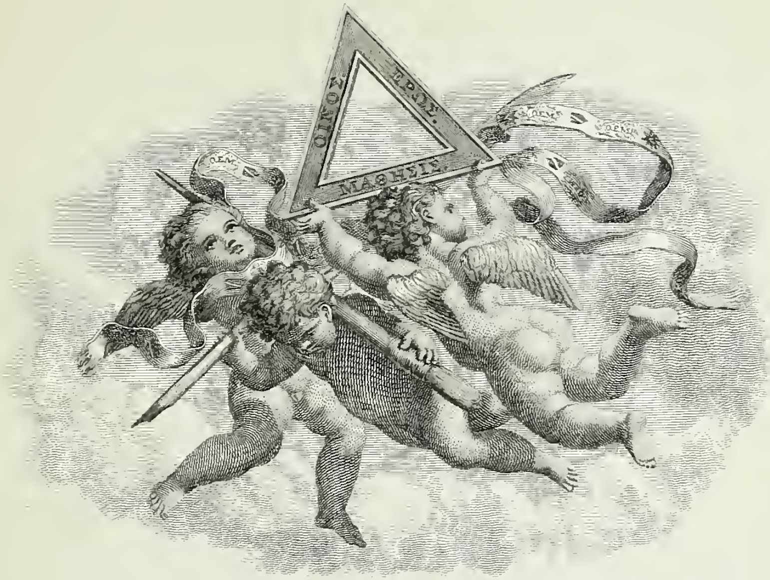
The brothers Goodsir tamed a seal and fed it on milk; it had its reservoir of sea-water. Then there were the great king-crab, chameleons, and other animals, which constituted a small menagerie and fresh sights for the privileged folk of Anstruther.

On February 18, 1839, Edward Forbes writes to

Goodsir—"You were unanimously united with us in the Brotherhood, so I now hail you as *Frater*." In offering an explanation of this laconic and mysterious note, the writer has to revert for a moment to Forbes's student-life, and his relationship with Goodsir, that being marked by a hearty co-operation in science and much pleasant sociality. In 1834-35, Forbes and a few other students formed themselves into a "*Maga* Club," whose objects were literature and good-fellowship—the latter for a time was probably the more demonstrative. The literature of the Club found vent in the "University *Maga*"—a weekly sheet of poetry and prose, and felicitous portraiture of lecturers, students, and snobs—that delighted every son of *Alma Mater*. Forbes, though foremost with both pen and pencil in the *Maga*, and distributing healthy satire and fun broadcast, was alive to a higher feeling of association than "Club nights," with *Maga* toasts and "Rule Britannias." He and his friends C. E. Stewart and D. Macaskill, therefore, resolved to found a brotherhood for mutual help and encouragement in their several spheres of occupation, be it Art, Literature, or Science. The Brotherhood, or "Order," as it was called, had a freemasonry repute among the uninitiated; and the words, ΟΙΝΟΣ, ΕΡΩΣ, ΜΑΘΗΣΙΣ (wine, love, learning), were adopted as the watchword. As symbolic of the "Order," the members wore across the breast a narrow silk ribbon, rose-coloured and black, with the mystic letters O. E. M. worked into its texture.

At the meetings of the "Order," the higher-class brethren wore a small silver triangle, with the favourite Greek triad engraved thereon. By outsiders, the men of the brotherhood were generally called "the red-ribbons," or "Oineromaths." The "good-fellowship" brethren, vinously reticent of the principles of the "Order," brought it into ridicule, if not contempt, so that, in 1838, it was needful to weed out those whose "bosoms glowed with oineromathic fire," and to have the earnest lovers of truth planted in the foreground; and these alone entered "The Universal Brotherhood of Friends of Truth."* Scrupulous care was exercised in the admission of new members, and of those only who had proved themselves worthy by works done, or by the show of a diligent pursuit after truth, and no less by the possession of a genial and hearty spirit to further the interests of the brotherhood. There were gradations in the "Order;" "frater," "triangle," and ceremonial officers—*ex. gr.* "the Bearer of the Mystic Lyre" and "Arch Magus." Forbes, after two years abroad, returned to Edinburgh (Nov. 1838); and among the first acts of the "Brotherhood" was the election of John Goodsir as "frater;" in November of the same year he rose to the honour of "triangle." The brotherhood consisted of men of different callings,—artists, scholars, physicians, natu-

* This title originated with Monsieur Jalabert, of St. Etienne, a staunch "frater," who got the beautiful ribbon of "the Order" manufactured in his father's silk establishment.



The Universal Brotherhood of Friends of Truth.

THIS BROTHERHOOD is a Union of the Searchers after Truth, for the glory of God, the good of all, and the honour of the Order, to the end that mind may hold its rightful sway in the world.

It is a Fellowship demanding of its Members earnestness, ability, and philanthropy, and recognising among them no distinctions of nation, party, rank, or profession.

Works done and approved, a sincere and loving spirit, and the energy to act, are the qualities required of the Candidate.

Love for the good and the beautiful is demanded of the Brothers, as well as the determination to seek for truth, and urge others to the search. Charity to all earnest opinions, kindness to all living creatures, and thankfulness for the blessings by which we are surrounded, are inculcated on the Brethren.

Co-operation in research, assistance in danger and adversity, advice and firm friendship, are extended by the Brethren towards each other.

The Triangle, symbolical of learning, love, and fellowship, and the Roseate Band, emblematical of their union, are the outward signs by which the Brethren recognise each other throughout the world.

ralists, poets, priests, and mathematicians. Less would have been said on this subject had not Goodsir come to be the *alter ego* of Forbes in the "Brotherhood," and given the last touches to the amended principles issued in 1841, a copy of which occupies the preceding page.

Goodsir was a noble example of the brotherhood that sought to bind man to man in ties of home and friendship, love and goodwill; he was a brother of help and of counsel in scientific research, and free from petty misgivings and jealousy of his compeers. No man, after Forbes—the *Archimagus*—showed a more catholic spirit in maintaining the principles of the "Order;" no one was more eager for the interpretation of truth, and few, if any, had greater hopes of a day of promise and fulfilment awaiting the patient investigation of organized bodies.

With these fraternal bonds came a renewal of the fraternal workings of Goodsir and Forbes, either at Anstruther or in Edinburgh, when the former could be spared from his father's practice. It was pleasant to see these men together—the Scot, of quiet demeanour, staid and studious; the Manxman, with long shining black hair, moustache, smart attire, sailor-freedom of manner—having so much in common, and such similarity of pursuits, so thoughtful at work, highly observant and gentlemanly. For a time marine zoology engaged them; but as years rolled over, the double star affinities of their scientific course diverged more and more. Human anatomy,

pathology, and morphology, occupied Goodsir ; whilst starfishes and the invertebrata so largely claimant of his earlier days, were no longer so exclusive with Forbes, extending his natural history survey over Europe, and with felicitous results in the Mediterranean.

In April 1839, Dr. Knox, anticipating the loss of his "Brother Fred's" services, solicited John Goodsir to join him in the anatomical lectureship, or, failing that, to arrange for his brother Harry taking charge of the "Practical Rooms." Being desirous, above all things, of lecturing in Edinburgh, Goodsir would at once have acceded to Knox's proposal, had he not been at that time in negotiation with the Dean of the Medical Faculty regarding the conservatorship of the University Museum. That Goodsir expected to move to Edinburgh, is shown by his taking No. 21 Lothian Street in May 1839 as a residence for himself and Forbes. Harry could not be spared from his father's practice.

The meeting of Professor Jameson with Mr. Goodsir in October 1838, alluded to in a previous page, and the growing belief that the museums of the University required reformation to meet the wants of anatomical and natural science, initiated a conference of the Medical Faculty. Early in 1839, the said faculty reported to the patrons of the University that the preparations of human and comparative anatomy, healthy and morbid, should have a special conservator. Professor Syme, who took untiring interest in the pro-

ceedings, communicated with Goodsir from time to time, and in October asked his views as to salary, it being taken for granted by the medical professors that he was the man for the work. Some difficulties arose as to funds for the new project; the lawyers got their fingers in, and the season passed. Jameson, full of hopes as he was of good-wishes to the conservator *in posse*, wrote to Goodsir, November 12, 1839:—"It has occurred to me, that as you will ere long be with us here, you might get up a paper on Comparative Anatomy for the 'Wernerian Natural History Society.' This will serve as an introduction to you, and let you be known in the College generally." As further proof of Goodsir's provisional engagement to the University, Jameson mentions his conferring with Alison and other colleagues, and adds—"It will also be desirable that you make as complete a series of marine mollusca, articulata, and zoophytes as you can for the collection here. I presume you have been busy with fishes." It was May 1840 when the money for the conservatorship was said to be soon coming, and full summer before Goodsir felt it judicious to leave Anstruther for his new vocation in Edinburgh.

Changes of import had taken place in the Edinburgh school of medicine since he left in 1835. A large majority of the extramural lecturers, in fellowship with the Colleges of Physicians and Surgeons, had constituted themselves a "Queen's College," in hopes of a phalanxed unity helping their interests. The University, though needing fresh blood, had most ex-

cellent representatives in Alison, Sir C. Bell, Christison, Jameson, and Syme. A monthly periodical was about to be started under the able editorship of Dr. Cormack, and in the ranks of "young physic" were observed graduates of great promise. The "Royal Medical Society," on the approach of its centenary (1837), had its presidential chair filled by such men as Drs. J. Y. Simpson, John Reid, Martin Barry, W. B. Carpenter, J. H. Bennett, and John Percy; the "Royal Physical Society" still maintained its eminent position; and the "Hunterian Medical Society" had for its senior president Dr. Samuel Brown—a host in himself. Drs. James Duncan and William Henderson, and others who cared less for the public display of societies, were no less worthy in illuminating the paths of progress, and promoting the fame of their "Alma Mater." Engaged in healthful rivalry, the men, and, it may be said, the societies generally, gave a happy direction to each other's efforts, and could not fail to be more or less formative of the school itself—a school of high reputation, but, like all institutions of historical maturity, wanting fresh breath and fresh indoctrination.

Though Goodsir had lost part of his bashfulness by lecturing at St. Andrews, and taking so active a part in Fife Societies, he still wore an air of reserve and the appearance of a closet student. The times were propitious to his casting off the rustic habiliments of his nature, and his associates, by their stirring example, were still more conducive to that end. Another day of biological discovery was dawning over Europe, and

Germany caught the first tangible ray—in the cell-genesis or theory of growth; and minds loyal to science were everywhere on the *qui vive* for the new developmental anatomy upon which to found a new physiology and pathology. Of his companions or coursers in the race it is needful to speak, as their example and work tended much, if a photographic simile can be allowed, to develop the Goodsir "negative"—to educe the finer lines, and to give breadth of tone to his scientific portraiture.

Dr. John Reid was at this time (1840) lecturing on physiology and acting as pathologist to the Royal Infirmary—his rooms there being the rendezvous of a circle of hearty friends.* His statistics on the comparative weights of the different human viscera, his observations on fever, and other pathological inquiries (in some of which he was associated with Dr. Henderson), proved the good use he made of his hospital position; his monograph on the eighth pair of nerves, and numerous original contributions to physiology, made him known to Europe. As the disciple of Haller, the pupil of Alison, and the promoter of new work, he did right good service. His rare modesty, mature judgment, and decision, were grafted upon a

* Of this circle only five members and the writer survive; the cheery Forbes, the solid Goodsir, the gracious Duncan, the brothers Newbigging, along with the central figure Reid, are gone. The writer may be permitted to say, *in memoriam* of so dearly valued a friend as John Reid, whose friendship and private confidence he enjoyed from 1836 to the close of his life, that his hearty, modest, and genial nature, his love of science and truth, marked him as one of nature's true nobility.

hearty noble nature. As a truth-seeking son of science, he exhausted the literature of his subject before he attempted a line of his own, hence his great success as a truth-finder and honest historian in physiology. He was an able critic of other men's opinions, and no less able expositor of his own—a German in toil, a Scot in caution, and ever averse to the rash and sensational French school headed by Magendie. Goodsir spent many an improving hour with Reid, to whose vigorous mind his own bore great affinity.

Dr. William Henderson, the pathologist and able diagnostic physician, obtained large and well-merited esteem among his compeers. He and Goodsir used to meet in the hospital to examine morbid products, and as rising men in the school were bracketed together as worthy of the professional elevation they afterwards attained. Though Goodsir was looked upon as an anatomist, he was exceedingly partial to pathology, and his observations on the fever of Anstruther enabled him to show the existence of those intestinal lesions which Louis and Chomel had described, but which few British observers had met with.

Dr. James Y. Simpson, the *protegé* and assistant-lecturer of John Thomson, was in the flowing tide of fame in 1840. An encyclopædist in medical lore, of winning manners and great natural abilities, and the writer of numerous original essays, he raised himself to the Professorship of Midwifery, and this distinction was but the prelude to his greater achievements in the medical art. His discovery of the anæsthetic power

of chloroform, and likewise of acupressure — Doric columns of the new temple of conservative surgery— his special insight into disease and his novel appliances to alleviate the sorrows of womankind, have materially aided in promoting a higher life and a happier social status. To-day Sir James Y. Simpson, Bart., stands alone in modern medicine, nor is he less distinguished in the collateral sciences—in archaeology and the world of letters.

Dr. Martin Barry, so much esteemed by Goodsir, was a man of silence and "of drab," yet ever true and philosophical. Quakerism has had within its ranks John Dalton the chemist, and Thomas Young, the natural philosopher, both of whom adorned the highest paths of science ; Martin Barry might be claimed as its greatest physiologist. He graduated in Edinburgh in 1833, and was the twelfth Englishman to ascend Mont Blanc (September 1834). He travelled much and studied more, wrote ably on embryology, and helped to indoctrinate the British mind with the new anatomy of the French and German schools. Barry and Goodsir may be said to have worked in the same field of inquiry; the latter practised his usual assiduity, but rarely attained greater success than was awarded the accurate and painstaking Quaker. They were loving friends, and their names are to be found associated in the field of histology and embryology ; the latter was Barry's *forte,* sometimes called his earthly idol. No man in Britain helped more to extend the horizon of cell-discovery during the first years of its history than

Dr. Martin Barry, whose researches are to be found in the *Transactions* of the Royal Societies of London and Edinburgh. His experienced use of the microscope, his indefatigable inquiries—sacrificing 150 rabbits to ascertain one fact in physiology, being almost equal to Haller's 190 experiments to determine the single point of muscular irritability—and thorough knowledge of developmental anatomy were of the greatest service to Goodsir. If any one of his contemporaries is to be pointed out as of more significance than the rest in calling forth Goodsir's higher aims and work, Dr. Martin Barry is the person entitled to the honour.

Dr. Allen Thomson—the son of John Thomson who wrote on various medical subjects, but is best known, as he is distinguished from his kinsmen, as "Inflammation Thomson"—was an anatomical lecturer in Edinburgh, who sought to extend his fame beyond his inheritance of good medical blood. He had been a colleague of Dr. Sharpey's, and continued his mode of teaching after his friend was transferred to University College, London. In elucidating the mysteries of the ovum, he was the rival of Barry; and now it may be said that no British name is more historically associated with embryology than his own.

Affecting his collateral studies, Goodsir rejoiced in the friendship of Dr. Samuel Brown, a young chemist of the highest promise. This "Brother of the Order" was a delicate, almost feminine-framed person, of manly heart and high mental endowment, who joined in the

poetic exaltations of Shelley, the erudite and metaphysical views of Coleridge, and the transcendentalisms of Goethe. Versed in the abstract, the abstruse, and the alchemical past of the Bacons and Van Helmonts, and daily sifting the current doctrines of Lavoisier and Dalton, he longed for a higher analysis than had been obtained by Cavendish, Priestley, or Davy, and the laying of a more permanent foundation for his glorious science. With the faith of Paul and all the zeal of Palissy, he sought, with saintly fervour, to break down the septum between man and the unknown, and to penetrate the arcana and very *adyta* of nature's temple. He was a profound thinker, with the hopes of a theoretical seer, heralding the time when the composite organic and inorganic worlds would be resolved by man to a simple element, and the subtle agencies of light, caloric, and magnetism to one entity. He worked at the transmutation of metals, not figuratively seeking the philosopher's stone that would reveal the unit or seminal principle of the world's constitution—the atom in the mighty chaos, the parthenogenesis or nidus of organic forms; or the molecule, isomorphic in relation or constructive of the earth's crust, and probably the foundation of universal orbs bearing the stamp of the Great and the Infinite.

Another chemist, Dr. George Wilson, also flourished in the Forbes and Goodsir "brotherhood"—a man of admirable talents, and well known for his biographical efforts, having a faculty of description in science and technology. Goodsir lived in close bonds with

Wilson, but he looked to Brown as the coming man of the new chemical philosophy.

Goodsir had a strong will and a disciplined mind, and no small share of ambition, and the cue to its promotion was within the circle of friends just described; there were other attached companions, of whom it is not necessary to speak in this general narrative.

His personality may be glanced at here, as he is shaping his plans within doors and busy preparing for the display of his best energies in a field largely competitive and exciting. He was now (1840) in the strength of his adolescence, and presented a tall, gaunt frame, whose height (75 inches) towered above all his friends. There was a grave if not sombre tone in his looks, increased by his brown hair combed downwards over his capacious forehead, his stooping shoulders, and downcast visage. His face, however viewed, was striking from its size; his prominent nose, deep and thoughtful eyes, large mouth and chin, and general expression, showed power, calmness, and perseverance. Walking along the street, he seemed entirely absorbed with his own thoughts, as if not living among the men of the world, but in a world of his own making. Yet there was an emphatic pronunciation of feeling in everything he did, and a manly consciousness of individuality; and in all his mental manifestations, an organized distinctness of feature or plan. If not always lucid in statement or bright in expression, he had nevertheless a thorough knowledge of his aim and work. In public societies he sat more like patience

on a monument than a scrutiniser of the proceedings; in private life he was disposed to taciturnity, excepting at home and among his own fraternity, where he enjoyed the humorous and the jocular with as much pleasure and risibility as his neighbours. His brain was large, and this active organ was engaged for sixteen or eighteen hours a-day, and often at high pressure —that damaging speed to humanity hastening to the goal of scientific discovery. In the ordinary relations of the world, he appeared retired and unassuming; but in the unreserved freedom of confidential intimacy, he showed himself possessed of a fair estimate of his own powers. It is no disparagement to say that he recognised his own talents, for the consciousness of power is not undesirable as a useful weapon with which to fight the battle of life. He possessed intellectual superiority, and was not without ambition to display it; occasionally the belief in his own powers carried him beyond his strength or hopes of attainment. In future pages it will be seen that the variety as well as number of his tentative efforts stood in the way of his rendering them so perfect and complete as they should have been, if he aimed them to be historical. His hands, colossal in size and muscular power, and not less fine in delicacy of action, were fitting instruments to his brain, and often in happy co-ordination with its manifold manifestations. When discussing science or theology, where the argument became warm and he was fairly in earnest, the big hand was raised significantly to support his dictum or his dogma.

He had not been a month in Edinburgh when the chair of anatomy and medicine at St. Andrews was declared vacant, and for a time it was supposed that by subdivision two professorships—"Anatomy" and "Natural History"—might be established. Goodsir and Forbes, in the belief that their lectures at St. Andrews and scientific contributions to Fife societies had given them a *locus standi*, were aspirants for the vacancies in contemplation. They took no public action in the matter, and were not ostensibly in the field of competition, so that the medical world of Edinburgh were not aware of their designs; nevertheless, "feelers" were thrown out by Goodsir's friends, and Forbes consulted some of the patrons of the University of St. Andrews. Of the candidates who appeared with testimonials, Dr. John Reid was the most popular and deserving, and in April 1841, he obtained the chair in its entirety, and with all its ancient privileges.

At the British Association Meeting at Glasgow (1840) Goodsir and Forbes read a joint paper on *Pelonaia*, a new genus of *Ascidian Mollusca*, and "Further Researches on the British *Ciliograda*." As partners in science and with congenial affinities, yet not without the contrasts of sentiment that improve social relationship, some of their friends approving highly of their services at this meeting expressed a wish to see them continue their joint labours as *collaborateurs* in natural history. Goodsir was anatomical, dry, and undemonstrative, whilst his colleague

was artistic and full of joyousness. Forbes's love of fun was strikingly seen in the first number of his work on starfishes, with the portrait of a pretty girl as a vignette. In writing Goodsir on the subject of introducing other Manx beauties, Forbes remarked—"That's rather a novelty, isn't it, Goodsir?" and assuredly to no man could the novelty have appeared greater than to the non-gallant anatomist. The Manx naturalist, whose line was more artistic than scientific, claimed the right to embellish the dry facts and drier technicalities of his zoological essays with his pencil; and the faces of pretty women were better than starfishes in more ways than the æsthetic.

CHAPTER V.

Wernerian, Royal Medical, and other Societies—Curator and Lecturer at the Royal College of Surgeons—Museum Work—Brief Sketch of the Cell-question—Goodsir's Claims—Virchow at Fault—Latest Doctrines.

In the full expectation of making a position in Edinburgh, and no doubt encouraged by Professor Jameson, who, along with Dr. Neill, proposed him, he became a member of the "Wernerian Society" on the 29th March 1840. His first contribution to the society (12th December 1840) was "On certain Peculiarities in the Structure of the Short Sunfish (*Orthragoriscus mola*), as observed in a large specimen captured in the Firth of Forth, near Alloa." He also gave an account of a species of parasite, which he termed *Gymnorhynchus horridus*, which affects it. The "Wernerian" being presided over by Professor Jameson, and ranking among its members every Scottish and many foreign naturalists, offered the best advantages to the young aspirant for honours in natural history. From time to time, and extending over a period of at least six years, Goodsir contributed a large number of papers (fifteen in all) either individually or along with his brother Harry and Edward Forbes. Thus in 1841 he read a paper on the Natural History of the *Echinus* and *Thalassema*, two genera of *Echinodermata*; and

in March 1846 a paper on the characters and anatomical structure of the *Hyperoodon dalei*, taken from a specimen stranded during the autumn of 1845 near Alloa; and in February 1847, on the Morphological Constitution of the Skeleton in Sponges; he and his brother Harry read papers on the Metamorphoses of *Cancer Mœnas* and *Cancer Bernhardus*, with descriptions of some species of *Caprella* in April 1842; and on a new Crustaceous animal, *Erineus splendens;* and on the Larvæ of *Balanus tintinnabulum* in April 1843. The greater part of his researches in comparative anatomy from 1840 to 1847, his description of "the Natural Features of the Dornoch Firth," and his observations "On the vast Accumulation of minute Marine Animals which precede the appearance of a Herring Shoal off the Isle of May," were laid before the Wernerian Society.

In the year 1840 he furnished his friend Mr. W. Thompson with an account of the anatomy of *Limnæus involutus*, which was printed in the *Annals of Natural History*, vol. v. p. 23.

His juvenile *penchant* for botany—of which no mention has hitherto been made, as zoology, physic, and palæontology, had proved too absorbing studies in Fife to permit of its growth and expansion—became revived by his residing in proximity to Arthur's Seat and the Braid Hills, and in having the "Royal Botanical Gardens" lying in the direction of the Firth of Forth. He joined the Edinburgh Botanical Society in 1841, and became its secretary in 1842, which office he held

till 1848, when he was chosen vice-president. His description of the fungus found on the gills of the gold-fish (*Cyprinus auratus*), and his papers on the *Sarcina ventriculi* and the potato-disease, were read to the Botanical Society.*

Goodsir joined the Royal Medical Society in 1833, but it was the session of 1840-41 before his presence became known in the hall of debate. Every one, however slightly acquainted with the Edinburgh school, knows the high status of the "Royal Medical," and that upon its roll are inscribed the honoured names of Thomas Addison, Richard Bright, Marshall Hall, Henry Holland, and others of metropolitan fame, with those of equal distinction associated with the Scottish and Irish universities and colleges—the men, in short, who have been most prominent in the history of British medicine and discovery during the last hundred years. In November 1840 Goodsir read his "Dissertation" to the society "On Changes produced in the Cæcum by Ulcers and Abscesses," in which he set forth that the partial obliteration or contraction of size in the cæcum and appendix vermiformis takes place according to a certain plan; and further, that "the normal and abnormal obliterating of organs and parts of organised bodies is conducted according to certain laws as definite as those which regulate their development." As the general result of his observation, he concluded—1*st*, That the cæcum and appendix

* An obituary notice of John Goodsir, from the pen of his loving friend Professor J. H. Balfour, is recorded in the *Transactions of the Botanical Society of Edinburgh*, vol. ix., 1866-67.

vermiformis may be partially or wholly obliterated by the contraction resulting from ulcers and abscesses; and, 2*dly*, That this was effected, in the cases which have been under my observation in a definite manner, by folding of the walls of the organ, and subsequent ulceration of the attached edges, and the two surfaces of these folds.—(*Printed in Cormack's Monthly Journal of Medical Science, April* 1841). He read a paper on continued fever in April 1842, marked by a full symptomatology of the disease, and a cautious observation as to the pathology being charged upon "molecular" or "structural lesions." The depletive system was in his eyes "the treatment suggested by common sense (a faculty of more use to the practical physician than all the science of Newton) and approved of by the experience of every age." Again—"A proper decision as to treatment requires experience, tact, and *long-headedness*." He was convinced that in time the country would be mapped out, so that the type of fever, cephalic or abdominal, prevailing in or rather peculiar to each district and town, will be ascertained by inspection of the map; and, lastly, believed that the type of fever varied according to circumstances, social, meteorological, and geological, with the laws of which we were not yet acquainted. He was elected Senior President of the Royal Medical Society in 1841-2, and continued in office the following year to every one's satisfaction.

The "Anatomical and Physiological Society,"

founded by Knox in 1833 and for a time in abeyance, was resuscitated in the session 1840-1; Goodsir resumed his membership in the society and became president in 1841-2. He made several communications to the society of minor interest, and in April 1842 for the first time gave his views on the structure of the liver and kidney.

He became a member of the Royal Physical Society in December 1841, and in the spring of 1842 read papers on the Development of the Skeleton in the series of invertebrate animals—the skeleton of the Radiata he illustrated by various preparations and diagrams. He also gave an account of the medusa, its method of producing its kind, both by its polypes and perfect forms. On the 12th December 1849 he was elected one of the three presidents of the "Royal Physical," and remained in office for three years—until November 13, 1852. He should have delivered the opening address in November 1851, but was prevented by indisposition. His paper on the structure and economy of the "Compound Tunicata," his exhibiting a specimen of a new genus *Syntethys* from the Hebrides in March 1851, and giving a few anatomical details of the new species of *Malapterurus* in April 1855, constituted, with the essays mentioned above, the whole of his contributions to the Royal Physical Society.

The appointment of Mr. Macgillivray* to the chair

* There were several applicants for the Aberdeen chair, and much pressure brought to bear upon the Government. Macgillivray modestly contented himself with sending copies of his works on birds and natural history, along with

of natural history in Aberdeen caused a vacancy in the conservatorship of the museum of the Royal College of Surgeons, Edinburgh. Goodsir felt anxious for the post, and in setting forth his fitness for it stated that he had practised every department of preparation and conservation; that he had considerable experience in modelling in clay, plaster, and wax, and in the use of microscope and pencil; moreover, his own collection of preparations in human, comparative, and morbid anatomy exceeded 400 in number. The character of his testimonials and the weightier credentials of work done and exhibited rendered all competition useless, with the exception of a local candidate of good claims, who, finding the prohibition of surgical practice a *sine qua non* in the conditions binding the curator, also withdrew his name before the day of election. Goodsir therefore succeeded Macgillivray on the 21st April 1841. In the matter of pay the situation was wretchedly poor, but the opportunities it afforded for study and investigation made it rich and valuable in Goodsir's eyes. His letters on his appointment sounded of the *Io triumphe* strain, not without a prospective Alexandrian spirit of more worlds to conquer. Those who knew but the outside of the man in his reserved attitudes would never have dreamt of such a feeling of exultation pervading Goodsir, much less of the joy he exhibited on obtaining a curatorship of £150, *minus*

a note to Lord Normanby, the Home Secretary, who, throwing aside party considerations, promoted this true lover of the natural sciences to the chair—an acknowledgment of merit on the part of a minister of the crown as honourable as it was judiciously and handsomely done.

certain deductions for assistant, leaving a net income of £120 a-year! The Surgeons' Museum, containing the Barclayan collection of comparative anatomy, great numbers of highly valuable preparations by John and Charles Bell, and numerous contributions of the Fellows of the College, afforded a large and instructive field for observation. Goodsir benefited by the labours of his predecessors in office, and notably by those of Dr. Knox, who in 1825 had classified and catalogued the physiological and natural history series, and aimed at a new order of things, illustrating human and comparative pathology —the utility of which, though not recognised at the time, cannot fail to be appreciated now.

About this time he sold his pathological preparations, many of which illustrated the intestinal lesions which he had studied with such care at Anstruther, and which had enabled him to give so full an account of the fever of his home locality.

On the 16th May 1842 the committee of curators reported favourably of Goodsir's work in the museum during his year of office; and at the same sederunt the College accepted his offer to deliver a course of lectures on subjects that could be illustrated by the collection, in the hope that his lectures would extend the usefulness of the museum and promote the interests of the College generally. He gave a dozen lectures during the summer; and it could not fail to be viewed as highly complimentary to him as a curator that they were attended by professors, medical practitioners, and advanced students. It was

sound policy on his part to appear as a public lecturer, for without some proof of his capabilities in that direction several avenues would be closed to his progress—the very avenues he longed to see open to fair competition. To practise public speaking, and to give a prominence to his knowledge of several points in anatomy and pathology, were strong motives for his making the attempt—naturally a bold one—before an audience composed of the *élite* of the medical profession in Edinburgh, whose presence indicated their hopes of getting information, and breadth and originality of views, from the curator. As a lecturer at the College of Surgeons, it was said that Goodsir's matter was very much better than his manner. Not aided by dress, or deportment, or even personal appearance, wanting in rhetoric, devoid of gesture, and dealing out monotonous sentences for upwards of an hour together, were severe drawbacks to his success; nevertheless, Goodsir had the art of engaging his audience and keeping up the number of his class to the end of the course. No one could fail to see his extensive knowledge of the subjects he discussed, his appreciation of the collection under his charge, his practical or rather surgical aims, along with his cultivation of the higher anatomy; and Professor Syme, on moving a vote of thanks to him at the finish of the course, but echoed the general sentiment of the benches, in saying that Goodsir's lectures had been highly instructive and valuable.

Goodsir's work in the museum partook more of a

refitting and renewing of the old than any building up or re-construction of new materials. Skeletons were rearticulated, osseous specimens were mounted on stands, wet preparations were restored and redisplayed in spirit; and an improved appearance given to the entire collection. The new preparations put up by him are included in the manuscript of the general catalogue, written in his own handwriting—Nos. 2222 to 2270, including 29 pathological (both surgical and medical), and 20 specimens of comparative anatomy, principally from the conger eel, dog-fish, and the American ostrich. The character of his work is visible enough for its neatness and the clear exposition of what should be made apparent in each preparation. In November 1842 Goodsir proposed to the curators to demonstrate the preparations in the museum to the medical students on Saturdays—a great boon to those who wished to avail themselves of a thoroughly practical acquaintance with the collection. These demonstrations assumed very much the character of lectures, and not unlike those given in summer.

If the College of Surgeons' Museum benefited by the Goodsir curatorship, the curator himself derived considerable advantages during his tenure of office. The variety and extent of the collection afforded much light to a man gifted with precision of observation, and that observation materially heightened by the use of the microscope. Possessing experienced manipulative and good ocular powers, Goodsir suc-

ceeded in clearing up the nature of several preparations and gathering a clue to the unsolved problems affecting their history. Each *éclaircissement* afforded a fresh starting-point to further inquiries, and Goodsir was not the man to slacken the rein or spare the whip as goal after goal came into view, indicating the terminus as still beyond. The night's study at home hardly kept pace with the daily observations in the museum. From time to time the societies were informed of his work, for Goodsir, looking beyond his present status (1842), had become persuaded that he should lose no opportunities of obtaining public acknowledgment and approbation. "The times" were as advancing and aggressive in the biological as in the political world. No man of enterprise or ambition thought of hiding his talents under a bushel in the midst of such competitive forces as existed in the Medical School of Edinburgh, of which a sketch has been given in the previous chapter. Moreover, in his special walk of anatomy great strides were being made, and notably in Germany and France—which nations, along with Italy and England, constitute the four "Great Powers" of science in Europe.

Historians seem agreed that each grand epoch in the art or science of medicine has derived its first impulse from a new anatomy, originating a higher physiology and theory of disease. Galen, though learned in the philosophy of Plato, the physics of Aristotle, and the aphorisms of Hippocrates, was little known for these acquirements; but his anatomical

pursuits in the school of Alexandria gave him a living reputation and a permanent niche in the temple of Æsculapius. He was ranked as an innovator in his time. The same fate surrounded Vesalius, whose anatomical light shone like an eastern star upon Europe after mediævalism had passed away. Nor did Harvey and Bichat escape the imputation that befel their predecessors. All of them were, happily for science, innovators on the past. And here it may be well, however cursorily, to notice another innovation upon the old domains, as Goodsir took a very prominent part in the work, and rested no small share of his reputation upon the Anatomy of Tissues or Histology.

The curiosity of ages as to the cosmic atoms, the corpuscles, and genetic forces of life, came to be solved in the manner that Sir Isaac Newton had anticipated—namely, by the use of the microscope. In 1838, Schleiden and Schwann announced their discovery of the primitive organic corpuscle or "cell," and to them every honour is due; nor is there any desire to detract from their merits in saying the groundwork of their observations was indicated in 1825, when, at the jubilee of Johann Friedrich Blumenbach's graduation, celebrated at Göttingen, and echoed throughout "The Fatherland," Purkinje of Breslau announced the germinal vesicle in the ovarian ovum of birds. Purkinje's discovery received further amplification at the hands of Von Baer and R. Wagner, and subsequently in the viviparous animals,

by Von Baer, Prevost and Dumas, Valentin, and others. Had W. Hewson's observations on the "central particle of the blood (1773), and R. Brown's on the nucleus of the vegetable cell (1831), been fully extended, England would have anticipated Germany in the cell-discovery. Though Müller's recognition of the cellular structure of the chorda dorsalis, and the researches of Henle and Valentin on the epithelium and animal textures, as well as those of Mirbel on plants, had been published, and though eminent embryologists, including those named above, and Rathke, Barry, Bischoff, and Allen Thomson, had the primitive organic structures under observation, it was left to Schleiden and Schwann to establish the first base-line of the new histological survey. It soon came to be recognised that, however diversified in character the tissues of organized bodies might be to the eye, the microscope revealed a remarkable uniformity of character in their growth and construction; and further, that all vegetable structures, and many animal, originate in minute corpuscles having more or less of a vesicular structure, named "cells." These cells, constituting the germs of the tissues, are embryonic elements, and the history of their growth and metamorphosis corresponds in a great measure to the changes observed in tracing the germinal vesicle in its progressive stages of development into the different textures of the animal organism.

The discovery of the Germans came at a good time to refresh the physiological mind of Europe. Though doing a fair amount of work in biology, England

seemed satisfied with Sir C. Bell's discovery of the functions of the nerves, and Dr. Marshall Hall's exposition of an "Excito-motory System"—the extension and application of the views of Whytt and Prochaska to modern theory and practice, as her great achievements in the century. In anatomy she furnished no works equal to those of Beclard, Tiedemann, and Cruveilhier; while her physiology was much indebted to Blumenbach, Müller, and others. The English *Cyclopædia of Anatomy and Physiology*, edited by Dr. Todd, was a step in advance, for each fasciculus of the work indicated the rise of men worthy of honours in the country of Harvey, Hunter, and Bell. In comparative anatomy England owed to Richard Owen her high position in Europe; and though entitled to a fair share of the felicitous observations gracing the field of physiology, she seemed more or less disposed to rest on her oars, apparently reticent as to the belief that each decade should make its own impress on the century's scroll, and that without such impress history becomes negative, letterless, or *nil*.

Bichat's *Anatomie Generale*—a work enough for any man's immortality—had satisfied more than one generation; but with the advancing spirit of the age, and a better use of optical appliances, arose the Purkinjes, Von Baers, Müllers, Browns, Schleidens, Barrys, and Sharpeys, to illuminate the large field of biology. It was not the tissues, *per se*, as seen by the naked eye, or in their chemico-physical relations, but their embryonic genesis, elaboration, and metamorphosis,

that were now to engage anatomists. The lens and the doublet were discarded for the compound microscope, and this has afforded a new revelation to men of eyes and brain, exploring the minute structures of organisms. As another *eureka* in history, the discovery of the "Cell" or organic corpuscle merited "All Hail!" but it would be no less hasty than unphilosophic to claim for it the *ne plus ultra* of man's aim in the field of physiology. To-day the words of Laplace are as appropriate as when he uttered them on his deathbed—"Ce que nous connaissons est peu de chose, ce que nous ignorons est immense." Moreover, fresh problems in physiology, quite as much as in physical science, are continually presenting themselves for solution, and one discovery is but an introduction to many others, as startling as the "All Hail!" or the regal shadows crossing Macbeth's vision:—

> "And yet the eighth appears, who bears a glass
> Which shows me many more."

As the century entered its fourth decade, "the cell-question," viewed phytologically and zoologically, constituted a new epoch in science; whilst in import, in scope, character, and excellence, the microscope rose to a higher and higher perfection. With cell-growth as a primary fact in the tissues of organized bodies, all that was needed was a true and fervid cultus on the part of intelligent minds to render the epoch worthy of its appliances, its aims, and its destiny. Every one, it may be said, owes something to his epoch; some men owe their happy lines in life entirely to theirs; and not

a few in these latter days have assiduously sought and gained reputation through the agency of the microscope applied to the investigation of organisms. The revelations of this instrument came as a great tide in 1840 that wafted Goodsir and many others to havens of discovery, and those proud positions in science which many seek but few obtain. Though Germany took the lead, many able cultivators occupied English ground. Ranking with the London school, and early in the field, Sharpey,* Bowman, Carpenter, Gulliver,† Busk, Simon, and Paget may be worthily cited as representing every department of the cellular theory; whilst in the Edinburgh school Martin Barry and Allen Thomson shone in embryology, and J. Hughes Bennett in both physiology and pathology, and Goodsir traversed a wider range human and comparative. Of late years the list of those who have aided the cause of cell-interpretation, or added to the general stores of histological facts and hypotheses, is greatly extended; indeed of

* Dr. Sharpey leetured on anatomy in Edinburgh from 1832 to 1836. He systematieally used the mieroseope for the purpose of illustrating his anatomieal course. Previous to 1830, he made his valuable observations on "*Cilia*," and used Woollaston's doublet 1-20th of an ineh foeus. Dr. Allen Thomson followed Sharpey's method of teaching, and his embryologieal researches demanded the use of the mieroseope. Goodsir had an Oberhaeuser to aid him in his inquiries into the development of the Invertebrata of the Firth, and also the oeeasional use of Dr. John Reid's microseope, and one of Charles Chevalier's manufaeture belonging to the writer, and probably also that of Dr. Martin Barry.

† Mr. Gulliver's translation of Gerber's Anatomy in 1842, and his own notes and observations and defenee of the English Sehool of Anatomists, served an exeellent purpose. In editing the works of William Hewson, F.R.S., for the Sydenham Society in 1846, he indicated that Hewson had nearly anticipated Sehwann's diseovery of the eell as far baek as 1773.

the advocates and partisans of the new doctrines carried to a legitimate issue, or possibly somewhere beyond, it may be truly said, "the cry is still, They come."

Like all the early observers of "the cell," Goodsir met with difficulties. Granted a cell, with its walls, its contents, its nucleus and nucleolus, what then? Did the formation of cells depend on an endogenous or exogenous growth, a fissiparous division, or a gemmiferous thrusting forth of new cells or materials? Theory often ran in advance of observation, and Goodsir, too anxious for a foremost place in the race of competition, went boldly onwards; for, with too many of that period, instead of comparing microscopic observation with the data furnished by the test-tube and the philosophical balance, the desire was to be able to cry "Eureka!" before your neighbour. This mode of procedure could excite no surprise; histology was an almost untrodden field, the explorers of which were enthusiastic and impressionable. The new developmental anatomy attracted *dilettanti* and idealists, as well as the legitimists in science, and came to be viewed in the highest light as an Archimedean lever to the biological world—a consummation devoutly to be wished by the physicist, physiologist, and positivist, all of whom took part in the discussion of a subject that seemed specially to concern the anatomist alone. The geometrician saw the fundamental form of nature represented in the cell—a hollow spheroid or ellipsoid; the physiologist would have it that all the processes engaged in the vital functions rest upon a combination,

recombination, or multiplication of cells; and Comte, rising with his philosophy still higher, found in the life of the single cell a type and the source of not only the functions of individual man, but also of the *grand être*—humanity. Even the lover of the æsthetical, struck by the histological elements, both in their origin and coalesced functions, glorified them into a form of beauty charmingly consonant with his *beau ideal* of life, and his higher aspirations towards the primitive æsthetic standard. Goodsir, no less speculative than scientific, was not the least conspicuous supporter of the new doctrines that bid fair, at one time, to make the cell the whole science of life.

Of the lectures delivered in the theatre of the Royal College of Surgeons in the summer of 1842 and winter 1842-43, a portion was devoted to the consideration of practical subjects—*ex. gr.* surgical pathology; another portion embraced anatomical and physiological questions of current or rather special interest to the younger members of his audience, and were afterwards woven into a work—"Anatomical and Pathological Observations," (*vide* vol. ii. p. 387). The prominent doctrines enunciated by Goodsir in these lectures mainly rested on the existence of centres of force connected with the nutritive and reproductive changes in the normal and pathological processes. The term "centres of nutrition," or "germinal centres," as employed by him, obviously possessed a similar signification to that which at this time is attached by Dr. Beale to his "germinal matter," and by various anatomists of the

most modern German school to their masses of nucleated protoplasm. The allocation to these definite "centres," not only of the forces engaged in the nutrition of the textures, but in the reproduction of new forms both in normal and pathological processes—a doctrine which has been in its special relations to pathology so systematically pursued by Virchow and his disciples—was unmistakably present in the mind of Goodsir, and also articulately expressed in the pathological papers in the series now referred to. This, it must be remembered, was at a period when the origin of new cell-forms by a process of precipitation, or molecular aggregation in a fluid blastema or exudation, was the doctrine prevalent in the schools.

Of the part which the nucleated cell plays in the processes of nutrition, secretion, and reproduction, normal and otherwise, it may perhaps suffice to refer the reader to the paper on "Centres of Nutrition," to that on "Absorption and Ulceration, and the Structures engaged in these Processes," and "On the Process of Ulceration in Articular Cartilages;" to the memoir on "Secreting Structures," and the short essays on the "Structure and Economy of Bone," and on the "Mode of Reproduction after the Death of the Shaft of a Long Bone." Corroborative evidence may also be met with in his memoir "On Diseased Conditions of the Intestinal Glands," and the paper on the "Structure and Pathology of the Kidney and Liver." In these various essays the presence of the products of secretion within cells; the increase which takes place in the size of the cells,

and the multiplication of their nuclei when influenced by morbid changes; the rupture of these enlarged proliferating cells, and the discharge of their nucleated contents; the destruction, scooping out, and solution of textures by the action of the forces residing in these new formed structures; the presence of soft nucleated masses in the lacunæ and Haversian canals of bone, and the part which they play in the absorption of bone; and the changes which take place in nucleated cells in connection with cyst-formation—all testify to the largeness of his observation of cell-life, both physiologically and pathologically.

In the first of these memoirs not only does he advocate the importance of the cell as a centre of nutrition, but argues that the organism is subdivided into a number of departments, "each containing a certain number of simple or developed cells, all of which hold certain relations to one central or capital cell around which they are grouped." This idea has since been freely made use of by Professor Virchow, though, it must be admitted, without a due acknowledgment of the quarter in which it was originally stated, and it has obviously influenced many of his physiological and pathological speculations. This reticence is the more strange, as Virchow dedicated his work on *Cellular Pathologie* to the Edinburgh professor in the following complimentary terms:—"To John Goodsir, F.R.S. etc., as one of the earliest and most acute observers of cell-life, both physiological and pathological, this work on Cellular Pathology is dedicated, as a slight testimony

of his deep respect and sincere admiration, by the author." As Professor Virchow has travelled over much of the ground that had been previously cultivated by Goodsir, it is no less remarkable than disappointing to find in Virchow's volume of 433 pages but one reference to Goodsir, and that in connection with an observation the merit of which might be more fairly ascribed to Dr. Martin Barry. This is scanty civility to a scientific *confrère* whom he has called "one of the most acute observers of cell-life,"—one whose labours he has availed himself of, and whose opinions and words he has occasionally adopted.

In his paper on the "Morbid Changes affecting the Glandulæ Aggregatæ of the Ileum in Fever," Goodsir (vol. ii. p. 377) describes these changes to be of the following nature—viz. "the development of cells within the constituent vesicles of the patches to such an extent as at last to burst them, or cause their solution; the continued increase in the number of the cells proceeding from as many centres as there are vesicles in the path; the conglomeration of the whole into one mass above the sub-mucous and under the mucous membrane, the distension of the latter, and the necessary ulceration and sloughing of the mass arising from this circumstance." This is clearly Virchow's "proliferation of cells." Then, in p. 390 of the same volume, Goodsir, speaking of simple or developed cells holding certain relations to one central or capital cell, says—"It would appear that from this central cell all the other cells of its department derive their

origin. It is the mother of all *within its own territory.*" If the reader will be at the pains to compare the whole paragraph from which this passage has been quoted with a paragraph at p. 14 of Mr. Chance's translation of Virchow, that terminates with the word "*cell-territory*" (zellen-territorien), he cannot fail to see the close following or copying of Goodsir. Virchow, however, makes no reference to the source from which he has obtained his cell-territory.*

Various opinions on the nature of the cell have passed current during the last thirty years, and almost each quinquenniad has had a theory of its own. Thus Schwann looked upon the *vitelline* membrane as the outer cell-wall, the yelk substance the contents, the *germinal vesicle* the nucleus, and the *macula* or *maculæ* the nucleolus or nucleoli. Wagner and Henle regarded the *germinal vesicle* as the true cell, and the other parts of the ovum as of the nature of superadded structures. Goodsir and Virchow held the cell to be the ultimate morphological element in which there is any manifestation of life, and that the seat of real action must not be transferred to any point beyond the cell. Still finer distinctions have been drawn of late years, and much said on "plasms" and "protoplasms" or "plasmodiums" as rivals of the cell. The observations of the eminent phytologist Hugo Von Mohl on the "Primordial Utricle," Cienkowsky's views

* This question was fully discussed in the *British Medical Journal* (Jan. 12, 1861), in a leading article—"Cellular Pathology, its Present Position"—being a review of Virchow's work as translated by Chance. The passages referred to in the text above are placed in parallel columns.

on the monads, espoused by Professor Huxley in his lectures on the *Invertebrata,* and Professor Haeckel's "Protogenes," may be cited in proof of the opinions afloat and pertaining to the ultimate atoms of organized bodies. The protogenes of the Jena professor is described as "simply a minute drop of living jelly, simpler even than a white blood-corpuscle, having no nucleus, no nucleolus, no contracting vesicle—'no nothing' in fact, except the property of flowing in various directions, and of protruding innumerable fine processes or pseudopodia." Here is a living substance devoid of all but molecular structure, yet showing by its pseudopodia the actions attributed to the lower forms of animal life—*ex. gr.* the *Amœba.* The question will now arise, If Haeckel's views be admitted, is plasm endowed with a formative and selective power in the building up and the disintegration and decay of organisms? Has science revealed a potential or pantheistic force—the universal Archeus—pervading every form of organized matter? Is it to be inferred that life is originally stamped on the amorphous and elementary molecule, that the molecule is advanced to a distinct and tangible organization in the cell as in the amorphozoa—the perfection of tissue being a further process of the cell in its entirety—anatomical and physiological? However this may be—and all that pertains to molecular morphology* is likely to

* "A Sketch of a Philosophy—Part II.—Matter and Molecular Morphology," published by Williams and Norgate, 1868, will furnish abundant materials to those interested in these inquiries. The chemical or elementary

undergo a thorough inquiry—Dr. Macvicar and others have space and verge enough in determining the intricate philosophy of matter. In all speculations resting on molecular and cellular growth, it may be well to remember that the dogma of to-day may come to rank with the disbelief of to-morrow, or even be classified with an antediluvian past; and it is not less necessary to keep in view what history has oft recorded and repeated, but in vain, that the eccentricities of one age may become the wisdom of the next.

synthesis, rather than the anatomical and physiological relations of molecules, are discussed in this remarkable *brochure*.

CHAPTER VI.

The Domicile of the Goodsirs, its Peculiarities and Attractions—"Noctes Lothianæ"—A New Curatorship—Salmonidæ—"Sarcina Ventriculi" and other Inquiries—Demonstrator and Chief Curator.—His Theories Modified.

The domicile of the Goodsirs in No. 21 Lothian Street, adjacent to the University of Edinburgh, was approached by a public flight of stairs, to which six different families had access, and consisted of the half of a top flat or storey, with attics—rented at £17 a-year! In character it ranked with the dwellings of petty tradesmen, and though the rooms were small they accommodated two or three brothers Goodsir, Edward Forbes, George E. Day—all very tall men, also their visitors, and a housekeeper or cook, and two lads who acted as anatomical assistants in the museum and as grooms-in-waiting at home. Man was not the sole occupant; other living things—biped, quadruped, manuped, and nulliped—had their share in the fortunes of the household. "Jacko" the monkey,* "Coco" the tortoise,

* "Jacko" was a droll customer, with a keen eye to his physical comforts. Looking upwards in the scale of being, or "aping his betters," he would have a vapour-bath, and in a mode that indicated neither propriety nor decorum. Watching his opportunity when the pot of boiling potatoes was removed from the fire, he used to warm his hips over the steaming vapours. Mr. Day having caught him in the act, vowed he would eat no more potatoes unless presented in their dry jackets. After Goodsir observed the parasite

"Cæsar" the dog, "Doodle" the cat, and occasionally guinea-pigs and urchins, had their freedom of run in the establishment; the birds were caged, and the great eagle stood Prometheus-like on his Caucasus; whilst shut up in the attics, or claiming part of the cook's precincts, and in improvised *aquaria* or *vivaria*, were frogs, fishes, molluscs, echinoderms, and various odds and ends of *Invertebrata*. These animals were nearly all meant for physiological observation, and occasionally furnished the anatomists with a blood-globule, a muscular fibre, and ciliated epithelium. As the ranks of this living motley fell away—for amidst such a marine, aërial, and land population life flowed and ebbed, and oft departed—the organisms, on ceasing their physiological functions, obtained the obsequies of the scalpel, the injecting-syringe, the spirit-jar, or macerating-tub; and, as mementoes of once familiar faces, skins and crania for conservation might be seen hanging like banners on the outward wall or attic's roof. This semi-menagerie and its mortuary relics, conveying to more senses than

on the gill of the haddock, Mr. Day came to have doubts as to the validity of fish in general; and as haddocks and potatoes were staple dishes in the establishment, his gastronomic squeamishness could only be allayed by Goodsir's assurance of the parasitic freedom of every fish, and the cook's declaration that "Jacko" was chained up during the preparation of the "gentlemen's dinner."

"Jacko," in a roving humour, descended by the spout on the outside wall to a lower storey, and finding the kitchen-window open walked in, to the great dismay of the female inmate. Knowing nothing of the curious household above, and being much engrossed, as nearly all Scotch folk were at the time, with the threatened disruption in the Kirk, Mrs. ——— looked upon the intruder, whose presence was as mysterious as his person was horrid in her eyes, as "spiritually uncanny;" nay, as "the chains were broken," had not "the thousand years" ended, and here was "Beelzebub himsel'!"

one decided anatomical impressions, bore a faint resemblance to a portion of the monastery of the Capuchins in the Piazza Barberini at Rome, where, however, the *genus homo,* and not the *genera animalium,* constituted a more degrading demonstration. Along with household furniture, boxes, big tomes, portfolios, fossils, geological and archæological specimens, were strewed about the rooms; the finer sorts of things occupied shelves; and these again variously set off by dried starfishes, shells, trophies of the chase, meerschaums, and the artistic or grotesque fancies of Forbes. As indiscriminate as the Paris *chiffonniers,* the Goodsirs fraternity hoarded up organic forms and their special idols, till they realised what appeared to bystanders a chaos of natural history and domesticity only to be surpassed by the oddest curiosity-shop in the Cowgate of the ancient city. With the owners, however, there was method in the midst of strange confusion, besides much pleasantry in the conceit, and a kind of æsthetic halo that crowned all the dust and cobwebs of their domicile.

Men born in the purple or nursed in the lap of comfort have no notion of the homes and habits of the student whose science is his stay and staff of life. The above sketch, though derived from a special instance presenting peculiarities apart from the general tone of things, will nevertheless, in its broader features, indicate the *status quo* prevailing thirty years ago in Edinburgh *quòad* men of philosophic aims unblessed with pecuniary resources. The Goodsirs and Forbes had been

trained or educated for a profession, but their natural *habitat* was science, and to that they gravitated without counting the cost or the sacrifice. They were like Sir C. Bell, who, in reference to his first settling in London, said—"I was as romantic as any young man could be, though the prevailing cast of my mind was to gain celebrity and independence by science, and perhaps this was the most extravagant of all." It was not choice or eccentricity, but the hard lines of the world, that drove them to set up their "household gods" in the attics of Lothian Street. Philosophers in theory, and full of adolescent hopes as to merit having its due reward, they had yet to learn that philosophy seldom, if ever, pays its own expenses in this country. Science they found to be the direst of economists, imperative in its demands for books, instruments, and other agencies, and more imperative still of brain-power, health, and vitality; yet the earnings it yielded in a highly materialistic age were but as Roman *denarii* compared with the "old Spanish dollar" and the fruits of commerce.

These naturalists had to trust to their brains and fingers, and these so actively and deftly occupied did not bring in £100 a-year. They were citizens of a free country—the wealthiest in the world—a country that hails scientific discovery as a mighty contribution to the national glory, yet seems to be unmindful of the arduous steps which have led to the consummation of the national boast. They loved science for its own sake, and the *nulla dies sine linea* of their lives was

their chief solace, heightened by a pleasant intercourse with men who, like themselves, could dine cheerily at a tavern for half-a-crown a-head, or on haddocks, potatoes, and whisky-toddy at home—even without the *paternum salinum*.*

> "Vivitur parvo bene, cui paternum
> Splendet in mensa tenui salinum;
> Nec leves somnos timor aut cupido
> Sordidus aufert."

England, with all her Reform Bills, had not come to recognise science, however ably and earnestly cultivated by her sons. Thus Harry Goodsir went out with Sir John Franklin to the Polar Seas in 1845, not in the capacity to which everybody knew he was credited, and for which not a dozen persons could be found in Britain so well suited, but ostensibly as assistant surgeon, whose duties could have been discharged equally well by hundreds of men. The Government were afraid to speak of a paid naturalist! With such an example at headquarters, the Universities pleaded poverty for their non-recognition of science; and to descend lower, neither the tribunes nor the people afforded encouragement to the pursuit of natural history. Forbes might well record—"The mass bestow more kicks than halfpence on science."

* The Goodsirs were not without the silver emblems of success in medical practice, and a very handsome cup presented to the patriarch "John" betokened the high esteem in which he was held by grateful patients. The "horned lantern," however, carried by "Grandfather John" to light up the dark paths of Fife, was quite as significant an heir-loom of the Goodsirs, and it stood on the mantelpiece in Lothian Street as a balance to a quaint Manx tankard—possibly the heir-loom of Edward Forbes.

Harry Goodsir designated No. 21 Lothian Street "The Barracks;" Edward Forbes, in his humbler strain, named it "The Attie," or in his higher flights, "Our Palace at Edinburgh." "The Barraeks" and "Our Palaee" seem very antipodal, but the estimate formed by these two men of their *locus in quo* was eorrect and charaeteristic enough. There was all the life, individuality, and colouring of a barraeks in their domieile, from whenee also the "Areh-Magus" and "Triangles" issued their ediets, and in kingly mood basked in the sunshine of their own enjoyment. The eourt-eirele of "Our Palaee" was highly select, and none but men of status in seienee, literature, and art could obtain an entrée. The ehoiee spirits of *Alma Mater* assembled in Lothian Street to talk and joke and expound the argument, and many an eneounter of steel against steel elashed under the Goodsir attics. There the observer eould have noted in full measure that whieh Benjamin Franklin had spoken of in his time as peculiar to men edueated in Edinburgh—a disputatious tone, a proneness to keen diseussion, with mueh loquaeity and oeeasional dogmatism; there also, as aeeompaniments of a hearty *symposium*, were skirmishes of wit and repartee, along with the more technical and seientific debate, not unfrequently setting the table in a roar. In seanning the panorama of the medieal school, with its moving figures and scenes of life, in commenting upon the wars of the hospital surgeons and the eontending claims of the physiologists, "The Barracks" found

gossip, fun, and laughter. The "old fogies," with cocked hats, stiff ruffles, and gold-headed staffs, had disappeared, even the last of the Hamiltons—the great obstetrician who styled himself "Junior" James in his seventies. Relics of the past, if such a term be applicable to humanities, were still visible—*e.g.* the senile professor, whose course, for any good got from it, might have been Sanscrit readings instead of "Cullen's Lines," the hour being filled up with his coughing, and hemming, and the uproarious sounds of his class; the evergreen *tertius* professor who unconcernedly at noon ate cranberry tarts in the midst of grinning students at a small pastry-cook's, and with digestion unimpaired the next hour read his grandfather's essays on Hydrocephalus as part of an anatomical course; and the quaint botanist and would-be philosopher who gave lectures in a sunless *cul-de-sac* of an old-fashioned square, and whose stock-in-trade was a beggarly account of unbleached paper-covers, enclosing tattered leaves and stems, and whose "fresh specimens for the class" were taken from the crown of his hat, once a gay and lofty beaver, but after countless years of service had become shapeless, napless, brown, and greasy, not the less in character, however, with the colour, dirt, and decadence of the man, his premises, and his prelections. How John Goodsir used to hold his sides, and Harry make the welkin ring with laughter, when more finished pictures than the writer's sketches were presented for their recognition and amusement; word-painting hardly sufficing without the imitative man-

ner and style, to depict the eccentric representations of the medical school.

Of the men who assembled at "The Barracks," note only can be taken of a few* of them in this sketch. It was no small treat to listen to Dr. Knox on his favoured subjects; his African experience of the Dutch Boer in contiguity with the agile Kaffir, or his special discoursings upon the history of race—his taking up for the nonce the credited unity of species, as biblically recorded, to show up, with greater force and a keener prophetic air, the racial divergences, dissensions, and antagonisms. It was not less rich to see Knox and Dr. Samuel Brown engaged in a passage at arms, be the subject of their controversy the atoms of Democritus, the vagaries of the "Illuminati," or the philosophy of Leibnitz. Within "Our Palace," history, ancient and mediæval, was fully canvassed and weighed in the balance of modern thought; and as every man convened to its tapestried reception-room had more or less of a speciality of pursuit, he got the opportunity of playing his favourite part, not seldom incited thereto by the quiet interrogations of John Goodsir, or the seductive leadings of Forbes. There John H. Balfour, redundant of botanic life, then as now, compared notes with the Manx herbalist; there John Goodsir

* Among the distinguished foreigners who ascended the long flight of stairs in Lothian Street, mention may be made of the famed Agassiz, who made his visit there after the British Association Meeting at Glasgow (Sept. 1840). Forbes wrote to a friend—"Agassiz was in ecstasies with the living urchins, star-fishes, and ophiuræ I showed him, and confessed he had never seen them alive."

and David Page resuscitated the quarries of Cornceres, the synods of Fife, and the bickerings of St. Andrews; there Forbes and J. H. Bennett revived their students' days, and sang their students' songs, of which the following stanza, part of an "Oineromathic" song written by Forbes, may be quoted:—

> "Then whilst we live we'll spend our hours
> 'Mid all that's bright and fair;
> In learning's fields we'll gather flowers,
> To wreathe in Beauty's hair;
> For wisdom's hoary locks we'll twine
> A crown of myrtle and of vine.
> Hurrah! hurrah for the Rosy Band,
> Hurrah for the Holly Tree!"*

Other minstrels of note visited the palace, and added to the charms of its many-coloured society by their presence, their songs, or their conversation. Among these may be mentioned Theodore Martin, of "Bon Gaultier" ballad fame, the able classic and man of letters, whose visits were more Forbesian; James Ballantine, the author of "The Gaberlunzie Wallet," whose poetic muse partook of the strain of Burns, and whose heart is still warmer than the sentiments of his songs; and Professor Blackie, exuberant in nationality and Homer's poesy, and keenly antagonistic of democracy. In "Our Palace" Dr. Day, afterwards Professor of Anatomy and Medicine at St. Andrews, was a resident, who oft displayed his skill of fence and facetiousness to the delight of

* The "Rosy Band" and "Holly" formed part of the insignia of "The Brotherhood of the Friends of Truth."

George Wilson, who possessed a fine susceptibility of the humorous; there Dobie, the artist and designer of the beautiful "Oineromathic" emblem given on a previous page, enjoyed the Punch-like cartoons of natural history by the arch-magus; there Dr. Samuel Brown, with his bright, penetrating, and transmutative character, had his outpourings of wondrous talk, charming to listen to, along with his analysis of the new chemical philosophy then dawning upon his brain—a philosophy of which everybody believed he was one day to be its high priest; there John Reid, in rubicund glow and fun, chaffed Harry Goodsir for assuming to have made the discovery of a separate sexual system in the barnacle, when both the male and female animals knew the fact, and had enjoyed the loves pertaining to the fact, thousands of years ago!

The *Noctes Ambrosianæ*—fiction or fact—found an historian of bold utterances who amused the readers of *Blackwood* with political gossip and fierce partisanship; the *Noctes Lothianæ* were of *bonâ fide* character, and breathed less of the oracular and denouncing, and more of the rational and philosophic. Forbes, writing from London, might well revert to the "tranquil, merry, and philosophical days and nights," spent in "Our Palace," and long to sing his favourite songs to an applauding audience. The writer, with his feeble pen, has no pretensions to record the *Memorabilia* of these Goodsir and Forbes "Noctes," he can but take a glance at those inspiriting scenes in which he played a

humble part; and conscious that such examples of "feasts of reason and flowings of soul" can have no revival to him on this side of the Stygian shore, claims indulgence for looking back upon them, much as the Eastern traveller homeward bound casts a lingering view upon the classic lands disappearing below the horizon, and bids them a last adieu.

Edward Forbes, when cruising in the Mediterranean on board of Her Majesty's ship "Beacon," from April 1841 to November 1842, wrote to Goodsir from various parts of the Eastern Archipelago, noting the droll creatures brought up by the dredge, and adding in one of his letters—"I often wished that you had been with me, as the structure of many of these unpreservable creatures would require your hand and knife to work them out." Nor did Forbes forget "the Brethren," to whom he sent love and greetings in every letter. Neither the ruined cities of Lycia, nor dredging the Ægean, nor contemplating the classic and biblical lands of the East, could efface his love for "the Order," and the delights of Edinburgh. Thus he wrote from the coast of Asia Minor—"I often heartily wish myself once more sitting over a tumbler of toddy, munching a Finnan haddy in our palace in Lothian Street." What charms existed in that top flat of a dingy thoroughfare compared with Eastern skies, Alpine scenery, and the grand historical? Forbes' heart was responsive to its pole; humanity carried the day, and Goodsir's attic and social intercourse stood forth as palatial and glorious! On his return Forbes visited

Edinburgh to arrange with the Goodsirs for the anatomical display of his collection as illustrative of the zoology of the Ægean Sea.

In June 1842, Goodsir was asked to go north to the Dornoch Firth to examine its zoology, so as to give in a report, and to furnish evidence in an important trial about salmon stake-nets. He was accompanied by Mr. James Wilson, and enjoyed his visit exceedingly.

In January 1843 John Goodsir was asked by Forbes to go before the Justiciary Court of Edinburgh, and save Mr. Yarrell the trouble of leaving London, and there explain the difference between a sprat and a herring; an anatomical question resting on the number of vertebræ*—the sprat having forty-eight, the herring fifty-six—the position of the ventral fin and serrated abdominal line in the sprat, the carinated but not serrated belly in the herring, and other minor points—as Dr. Neill considered sprats grew into herrings and that difference of vertebræ was a mere difference of age.

On the 12th May 1843 Professor Syme wrote from the University to Goodsir, offering him the curatorship "of the collection that has been or may be formed, through the means placed at the disposal of the Medical Faculty—salary £150 a-year, the appointment

* Some fishermen of Lord John Scott's had been summoned for netting herrings when fishing for sprats in the Firth of Forth, hence the trial before the court. Lord John remarked on Dr. Neill's opinion, that he never heard Methuselah had more vertebræ in his back-bone when he died than when he was a little boy, and that he was sure it was a *ruse* on the part of the old doctor in favour of the cormorants of Canonmills.

to be renewed annually; the curator to work five hours a-day in the museum, and five days each week." He was engaged to prepare a series of dissections illustrative of comparative anatomy and physiology, with a set of additional specimens of surgical pathology. As the emoluments were greater, and the position more desirable, than that which he occupied, he at once accepted Mr. Syme's offer. The salary of £150 a-year for the best man in Scotland, and perhaps the only man throughout the length and breadth of the land fit for the work, will sound strange to English ears; the fault rested not with Mr. Syme or his colleagues, for the funds of the University were not at their disposal. The College of Surgeons received Goodsir's resignation on the 16th May, and unanimously recorded "their perfect satisfaction with the great ability, faithfulness, and zeal with which he had discharged his duties, and of the very great and manifest improvement which the collection had undergone since it had been placed in his charge." His brother Harry succeeded him in the curatorship, and entered on his duties on the 31st July of the same year. It is worthy of remark, as illustrative of a family trait and special aptitude, that when Harry Goodsir vacated the curatorship in April 1845 for the Franklin polar expedition, he was succeeded by a younger brother, Archie, who acted for some months till the college could find a suitable person—Archie himself being bent on studying at Leipsic and Vienna; so that John, Harry, and Archie Goodsir successively occupied the position of curator

to the Edinburgh College of Surgeons between the spring of 1841 and the autumn of 1845, and did their work well.

In the summer and autumn of 1842, and onwards to the spring of 1843, Goodsir had much communication with Mr. A. Young, the Duke of Sutherland's salmon-fisher at Invershin, near Bonar Bridge, relative to the development and characters of the salmon in its progressive stages of growth till it became a mature fish. Mr. Young sent numerous specimens for Goodsir's inspection and preservation. A grilse was caught on the 21st of June going down to the sea that weighed 9 lbs., into the fins of which a copper wire was twisted; when the same fish was caught on the 5th of April of the following year it weighed 14 lbs. Another that was marked on the 9th January 1842, about 4 lbs. in weight, was caught on the 14th July, and weighed 9 lbs. Several smolts that had been marked by cutting off the dead-fin of the back were sent in their grilse state. The first of these smolts grown into grilse came early in the season and was only small in size; a second was 5 lbs.; a third was 7 lbs. The numbers forwarded to Edinburgh Mr. Young hoped would satisfy Goodsir as to the growth of the salmon from the smolt to the grilse and full fish. In February 1843 quantities of spawn were also sent to Goodsir for examination and experiment. Dr. Knox and others had sought information of Mr. Young, but without success, as he wished his views to remain a secret till he could furnish more abundant proofs; moreover, he was partial to Goodsir following

out the inquiry *in extenso,* and dealing honourably by him; for in one of his letters he says to Goodsir—"You have the right end of the tether, if you hold on fair." The various specimens John received were sent off to his brother Harry at Anstruther to stuff in his usual way for preservation—John cautioning him to do them well, as so many people were interested in the business, and to be sure to keep the wire in the fin. Considering the great interest attached to the subject, it is remarkable that Goodsir made no use of Mr. Young's strong "tether," and that he left no papers or memoranda indicative of strengthening it. As late as the 27th October 1855 Mr. Young asks Goodsir if he had written anything on the history and habits of the salmon, as he had promised years ago. He had thought of writing on salmon and fishes in general, and frequently visited an Edinburgh fishmonger's shop for aid to his work; but this, like many good and useful plans, had fallen through when no longer possessed of health and strength to do justice to his intentions.

Goodsir's many-sided nature led him occasionally, and not always wisely, to wander from his own domain. Not content with the enlargement of the "cellular theory," and the various subjects engaging his attention in the museum, he took a fancy to chemico-physiological inquiries, and hoped, in conjunction with Dr. George Wilson, to give a course of lectures on this, an almost untrodden field since the days of the great French Revolution. Possibly his

thoughts ran in the direction that had yielded such large promise to Lavoisier, Laplace, and Bichat. For Lavoisier not only created chemistry, but explained the nature of the chemical phenomena in organisms; and he and Laplace were the first to show that the physico-chemical actions taking place in living bodies rested for their manifestation on the ordinary laws of physics and chemistry; whilst Bichat crowned the edifice of the new physiology by his *Anatomie Générale*, in which he sought to establish for each special tissue a physiological property of its own. Dr. Wilson was very sanguine as to the results of a co-operation with Goodsir, whom he styled "a noble fellow, a most excellent and original inquirer, and one of the most amiable and lovable of men." The anatomist, however, did not find time to carry out his wishes; it is doubtful if he ever made a beginning.

His contributions to the different societies in Edinburgh (1841-1844) show how earnestly he laboured for a front place in the ranks, hoping by all laudable methods to put himself in a favourable position for any more lucrative or substantial appointment which might cast up. One of these contributions relating to the *Sarcina ventriculi* in cases of pyrosis or "water-brash"—a pretty discovery of itself for any man to make—helped to disclose much that had been obscure and enigmatical in digestion. The perversity of the stomachic functions, caused by the presence of organisms which no gastric juice could control, was viewed as strangely curious. The *Sarcina* attracted most

attention in England, where stomach complaints disturb the gastronomical "John Bull," as the "sair head" does the plodding Scot, and "smotherings about the heart" affect the Irish Celt. The discovery attracted many by its novelty, though parasitical growth had for some time been a matter of discussion. In this country, Professor Owen (1832) detected the presence of a greenish vegetable mould in the lungs of the *Phœnicopterus*, and was led to infer that internal parasites embrace entophyta as well as entozoa. Italian, French, and German observers, and notably Meynier, Schönlein, and Langenbeck, had written on parasitic growths; and Gruby of Vienna (Valentin's *Repertorium*, 1841) had given a complete history of them, bestowing special attention on the crusts of the *Tinea favosa* made up of *Mycodermata*. Hughes Bennett in Edinburgh, Rayer and Cazenave in Paris, confirmed Gruby's views. Mr. George Busk gave an excellent review in the *Microscopic Journal* (December 1841) of all that had been done, and embodied his own researches with it, so that parasitic formation was one of the questions of the day when Goodsir discovered the stomachic enemy.* As *Sarcina* affects all phases of life, from Lazarus at the gate to Dives in the palace, Goodsir became involved in a large amount of correspondence with doctors and patients soliciting information and curative means. The history of the

* If Edinburgh was first made acquainted with the *Sarcina*, so was its *Philosophical Journal* the first to convey to the world, in 1819, Sir J. Herschel's researches on the hypo-sulphites—salts of such significance in counteracting the parasite.

case gave him position and authority as a minute and accurate observer in little explored fields, and where natural history pursuits afforded light to strictly pathological questions.

In May 1844 Goodsir was appointed Demonstrator of Anatomy to Professor Monro. In October 1845 he furnished the curators of the University Museum with a long report of the progress made during his period of office as their assistant, and offering large suggestions for the further improvement and application of the museum to the wants of the different medical professors in their teachings. Two months subsequently (December 1845), on the resignation of Mr. Mackenzie, the Medical Faculty appointed him the curator of the entire museum. As demonstrator and curator he had now attained an excellent position. During this session he gave a course of twelve lectures to the Edinburgh Philosophical Institution on Human Physiology, not without a protest being made by Professor Monro against his doing so.

The work done by Goodsir during these five laborious years (1840-45), and mainly recorded in the second volume, will speak for itself, and no doubt will receive a just interpretation at the hands of men of science. His papers on "Centres of Nutrition" and "Secreting Structures" are among the most valuable and original of the series. In the first-named he awards the initiative steps and discovery of the parent cell to his friend Martin Barry. His numerous observations, extending over a wide range of glandular

structure, fully confirmed the idea that cells are the structures which perform the process of secretion, and that the functions of nutrition and secretion are essentially alike in their nature. His own estimate of the paper read to the Royal Society of Edinburgh was conveyed to his father thus:—"I have proved in it that secretion is exactly the same function as nutrition, and therefore regulated by the same laws." Goodsir's views on the nucleated cell as the great agent in absorption, nutrition, and secretion, have been generally accepted, and now constitute established data in the science of physiology.*

To one form of "nutritive centres" as arranged both in healthy and morbid parts, he gave the name of "a germinal membrane," of fine transparent character, and consisting of cells with their cavities flattened, so that their walls form the membrane by cohering at their edges, and their nuclei remain in its substance as the germinal centres. This was a new reading to Mr. Bowman's "basement membrane" ("On the Structure and Use of the Malpighian Bodies of the Kidney, &c."—*Phil. Trans.* 1842). Concerning this "germinal" of Goodsir, and "basement membrane" of Bowman much variety of opinion now exists, and its existence as a distinct isolable membrane is denied.

* See the article "Secretion," by Dr. Carpenter, in the *Cyclopædia of Anatomy and Physiology*, and Dr. Sharpey's most excellent history of general anatomy, constituting the introductory chapter of Quain's Anatomy, jointly edited by himself and Drs. Thomson and Cleland—by far the best work on human anatomy that has ever appeared in an English dress, and most creditable to its distinguished authors.

The fibro-cellular framework of the kidney as described by Goodsir, or, as it is now termed, the "connective tissue," though denied by some observers, has been subsequently confirmed, and is now generally admitted. Goodsir abandoned the views he originally published as to the shedding of the epithelium from the surfaces of the intestinal villi during absorption.

The observations of Owen, Sharpey, Weber, Reid, and Dalrymple, had greatly extended our knowledge of the structure of the placenta and formation of the decidua, more especially as regards the enlargement of the follicles of the uterine mucous membrane, and the arrangement of the blood-vessels. Goodsir pursued these inquiries, described several modifications in the vascular arrangements, pointed out the relation of the capillary tufts of the placental villi to certain cells which he described, and recorded the changes which take place during gestation in the interfollicular portion of the uterine mucous membrane. With these arrangements Goodsir associated theoretical opinions in conformity with his ideas of cell function, and considered that the placenta performs, as is always admitted, not only the function of a lung, but also that of an intestinal tube.

He investigated the process of ulceration in articular cartilage, and pointed out that lesions of that tissue resulted from changes in the shape and size of the cartilage corpuscles with multiplication of their nucleated contents. He showed that the destruction of the cartilage might take place not only at its free

surface, but by the passage into its substance of nipple-shaped vascular and cellular processes from the bone on which it rests. The subsequent very extended series of observations of Professor Redfern* of Belfast have added to and modified our knowledge of this subject. He considers that the vascular membrane, which Goodsir described as concerned in absorbing the cartilage and causing ulceration, to be the changed substance of the cartilage itself, which goes on to form the cicatrix. He also directed attention to the changes, such as the formation of fibres, in the intercellular substance, and considers that ulceration is a process of molecular disintegration not necessarily attended by any change in the cells.

With rare exceptions, Goodsir held by his own views of the cell in growth, metamorphosis, and decay, and with great tenacity, as if heedless of those who followed him in the same path of inquiry; and he was not less reticent of the diversity of opinion prevailing in the schools—a diversity approximative to the *quot homines tot sententiæ.*

* Professor Redfern on "Anormal Nutrition in Articular Cartilages"—(*Monthly Journal of Medical Sciences,* 1849-1850).

CHAPTER VII.

Contest for the Anatomical Chair—Calvinism alarmed—Potato-Blight—His system of Teaching and its Results—Loved by his Class—The Success of his Pupils—Surgical Practice—Veterinary Relations and Agriculture.

From 1842 onwards, Mr. Goodsir had an eye to Monro's Chair of Anatomy. His College of Surgeons lectures, his contributions to different societies, and these published *in extenso*, or in an abstracted form in the medical and other journals, constituted the sign *à la mode*. To be aye doing something *in literas publicas referre* guided "Young Edinburgh" in its professional look-out. Each observation made a line in a testimonial, and lengthy testimonials weighed with a Town-Council looking for pennyworths of labour, as offerings for their big-pennyworth of University patronage. His list of publications showed a fine array of armoury for the professorial contest. As anatomical demonstrator and curator of the museum, Goodsir possessed a footing in the University which could not fail to advance his interests on the retirement of Dr. Monro early in the spring of 1846. He was first in the field for the vacancy; his credentials of work done presented no less than twenty-seven essays, singly or jointly, on human, comparative, and morbid anatomy; and his

testimonials, home and foreign, were unexceptionably good. There were other candidates averred for Monro's chair, and notably the name of Professor Sharpey of London was mentioned. The presence of Sharpey and Goodsir in the field deterred Professor John Reid and some others from applying. The happy relationship of Sharpey with his *Alma Mater*, his exalted position in the metropolis and eminent fitness for the chair, were fairly adduced by his friends as strong claims in his favour, and considerately used in the hope of withdrawing Goodsir from the contest, particularly as Sharpey's best friends were also his. On being made aware of what was expected of him, Goodsir, with no small emphasis, declared that he would not yield his claims to any man in Britain except Professor Owen, and that he would stand or fall on his own merits. With the bold son of Fife it was *aut Cæsar, aut nullus.* As Dr. Sharpey was not the man to present himself in humble suit to a Town-Council, and use flattering unction to consequential "Baillies," his friends withdrew his name from the contest some time before the election.

Whilst matters were still *sub judice*, a smothered feeling existed that Goodsir was not quite orthodox, or at any rate not very demonstrative of his religious belief. As one of his competitors stood high with the evangelical community—and this went for a great deal in a city that prided itself on its Calvinism—Goodsir had to bestir himself in other walks than the scientific to prove his fitness for anatomical teaching. There

was nothing new in this covert attack upon a man of philosophic character; the practice is as common as the rising of the sun. Religious bigotry has ever shown a fear or jealousy of scientific research questioning divine rights and ecclesiastical prestige. The knowledge of common things, or the devices for acquiring money-hoards, no matter how, can pass current as unexceptionably Christian; but the science that looks to the heavens above, or to the earth beneath, or the arcana of life in its myriad forms around, has too often had hard lines assigned its culture, or rather its cultivators. To appease the Gods, Socrates had to seek his *quietus* in the poisoned cup; to avoid the thunderbolts of the "Infallible Church," Galileo had to recant his belief in nature's unalterable physics; and so the world has gone on from the man-God exactions of Nilotic Thebes to the evangelical persecutions of these latter days. It was not enough for Goodsir to prove his philosophy and morals; he must show a clean bill of orthodoxy, or go to the lazar-house of a perpetual quarantine. Tests not truth, Westminster Confessions and not scientific capacities, ruled the patrons of the University, even in the appointment to a strictly scientific professorship; and they, as a Town-Council, were but the reflex of a Scottish feeling of disquietude as to philosophy in its relations to revealed religion. "The Institutes of Medicine" chair—closely allied to the anatomical one—had been contended for in Edinburgh only a few years previously by men of undoubted eminence; but the Unitarian physiologist, now vice-

president of the Royal Society, London, could not get a single vote—perhaps he blessed himself that he escaped the fate of Servetus; and the pious Quaker, though his claims were largely European, had to withdraw from the compromising and indefensible requisitions of "Tests" and "Oaths"! In Goodsir's case no harm arose; he was a Presbyterian of the Established Church, and sound to the core of Scottish beliefs, and more partial to the Bible than vast numbers of its teachers, of whom he complained for their scanty use of the "Book" in public worship. On the day of election to the anatomical chair, Mr. Goodsir obtained 22 votes, and Dr. Handyside 11 votes.

In January 1846 Goodsir communicated a paper to the Royal Society, London, "On the Supra-Renal, Thymus, and Thyroid Bodies," that was read by Professor Owen; and on the 11th June he was elected a Fellow of the society. It was said that his application for the honour of a seat in the Royal Society was signed by the most eminent anatomists and naturalists of the day. He does not seem to have done anything for "The Royal" after obtaining its fellowship, and his visits to the metropolis were by no means frequent.

The potato-blight that so frightfully ravaged the crops of Great Britain and Ireland from 1845 to 1847, and brought famine and fever to the land, was of too grave an import to escape Goodsir's attention. He studied and read a paper on the subject to the Botanical Society of Edinburgh (February 12, 1846); an abstract of it, and the discussion thereon, is to be

found in the *Annals of Natural History*, vol. xvii. p. 275 (1846). Goodsir looked upon the potato-disease as an epidemie, and that there was a general resemblanee between the rise and progress of epidemics and the appearance or non-appearanee of fungi from season to season. From this analysis Goodsir coneeived that, in attempting to explain the nature of the potato-disease, the fungi in the diseased tubers should not be overlooked. He held that the brown matter met with in the diseased potato was organie; his belief being based upon its peeuliar forms and position in the eells.

On attaining the ehair of the Monros, the pedestal of his highest ambition, Goodsir looked forward to the revival of the anatomieal sehool, to its being made worthy of the exalted position that eharaeterised it during the *regime* of the Monros *primus et secundus*, and more worthy still of the advaneing progress marking biologieal seienee in his own times. To extend the basis of his distinguished predecessors, and to improve the superstructure of Barelay and Knox, influeneed Goodsir's thoughts from the day he entered upon his professorship to the last session of his oecupaney. Standing in the main vestibule of the Æsculapian temple, and vested with the responsibility of preparing the minds of the novitiates for the higher cultus of medieine within, he felt the gravity of his position, and sought, with all the fervidity of his nature, to exalt anatomy as a seienee, and to make his prelections fresh, praetieal, and suggestive.

Whilst climbing up the steep of his anatomical Olympus, he gladly laid hold of every aid to the ascent; but, on obtaining the chair, he was much more wary and greatly less discursive with his pen, as if afraid of lessening the fame of his position by hazarding the publication of anything rash and speculative. He was now more solicitous about the completion and perfection of his researches than the number and variety of his papers. Now and then he contributed to the archives of the Royal Society of Edinburgh and the British Association; but these public appearances were to be viewed as manifestations of his ability to cope with the higher problems of his science, and to show that the successor of the Monros could hold his own in the advancing tides of a newer philosophy.

Anatomical teaching now became the predominant fact in Goodsir's mind, and he longed to make it consonant with the march of the science, so as to place his pupils on the boundary-line of modern thought and discovery. His first aim was the extension and improvement of the dissecting-rooms, which he placed under the superintendence of an active staff of demonstrators and assistants. His experience of the Edinburgh school made him alive to the fact that much of his success as a professor would be dependent on the character and amount of instruction afforded his pupils in the practical anatomy course. Having organised a thoroughly good system of teaching descriptive and surgical anatomy, he felt the need of

making the structural or histological part of his lectures equally complete. This he accomplished not merely by an exposition in words, or by the aid of diagrams of the minute anatomy of the tissues, but by demonstrating the structures or tissues under the microscope—the only true, nay essential mode.

His partiality for the "Tutorial System" in full force in the English Universities, and viewed by him as an important adjunct to the professor's teachings, made him solicitous to try a similar mode of preparing his pupils for the higher studies of anatomy. By this system of instruction he proposed (1.) To afford a more favourable opportunity of *seeing* and *examining* the structures exhibited and described in the public lectures on anatomy; (2.) To facilitate the attainment of *more precise* information than can usually be procured from a lecture; and (3.) To assist the student in keeping up with the public lectures, so that he may not fall behind the progress of the course. His complete course consisted of—1*st*, His lectures on anatomy, in which the structure of the body was systematically described; 2*d*, Anatomical demonstrations by his chief assistant, in which the body was demonstrated topographically, and from the surface inwards; and 3*d*, Practical anatomy under the superintendence of the professor and his demonstrators.

It took him five years to organise his plans. His system of teaching, when completed, came to be looked upon as the best that ever regulated the anatomical department of any British university or medical school.

For a time he conducted the microscopic demonstrations himself. Dr. Drummond, the author of the article "Sympathetic Nerve" in the *Cyclopædia of Anatomy and Physiology*, was his first assistant to be entrusted with the duty, and for eleven years (1856-67) the course was conducted by Mr. Turner—the present professor of anatomy. Goodsir looked upon the demonstrations of tissues not as a separate subject, but as a department of anatomy constituting an essential part of his course. Perfect teaching was his great aim, and this he believed and often emphatically expressed could only be accomplished by employing the microscope. It was this feeling, no doubt, which induced him to place on the first page of his "Dissecting-Room Note-Book" the Horatian maxim—

> "Segnius irritant animos demissa per aurem,
> Quam quæ sunt oculis subjecta fidelibus, et quæ
> Ipse sibi tradit Spectator."

His systematic teaching, marked by conciseness and method, was well calculated to call forth the energies of the student; and each year afforded larger and larger proofs of its entire success. There was nothing wanting in his system of instruction, and nothing better had been offered than the Goodsirian mode of furnishing the anatomical mind with a high standard of knowledge both theoretical and practical. As a lecturer, Goodsir appeared less happily endowed. He had no smartness of manner, no captivating courtesy, no rhetorical flourish, to win the favours of a class, yet no professor was more popular in the Uni-

versity, or had so many attached pupils. It is true that he had the advantage of having them around him, and knowing many of them personally in the rooms; but it was in proving his thorough fitness for his office, and his painstaking efforts to indoctrinate their minds, that won him the confidence and high esteem of his students. They looked upon him as a master of his art and a philosopher in science. They were first led to believe in him, then they came to admire and love him. His singleness of purpose, his devotion to duty, his conscientious wish to elevate the thought of his pupils and to promote the interests of the university at large, were deserving of all praise.

In aiming at distinctness, and a rigid demonstration of the anatomy, a formality or preciseness *sui generis* became a dominant feature in Goodsir's lecturing. He was fond of treating his subject in a series of propositions, and in a way that recalled the inexorable logic and precise style of the Scottish metaphysician of a bygone day, without flow of language or any special diversion or enlivenment. In manifesting his earnestness, directness, and completeness—his three great attributes as a teacher—it may be said that neither rhetoric nor poetic brilliancy could much avail him; it was otherwise with Knox in his historical flights. Though imperceptible to others, Goodsir was not without a vein of poesy mingled with a large æsthetic feeling that enhanced the beauty of form in his eyes, and rendered more patent the loveliness and adaptation in the mechanism and physiological

operations in the varied structures of organisms. Of the imaginative and ideal he had a larger share than he ever ventured to express publicly, even when treating of subjects capable of being illuminated by a lively sentiment. But he stuck close to his technical teaching and his teleological doctrines. Berkeley and Coleridge but rarely gained a Goodsir utterance; Shakespeare and Milton never crossed his path. As a matter-of-fact person, he continued the even tenor of his way, and seldom entered the arena of debate or controversial disputation. The marked exceptional instance to this equanimity of purpose was his buckling on the armour of orthodoxy to counteract the threatened inroads of human science upon the domain of his infallible *Pneuma.* In protesting against the new doctrines or hypotheses *quoad* man's origin and place in nature, he came forth in the strength of the Psalmist of old, not however in the language of Eastern imagery, but in bold Scottish vernacular, admitting of no compromise. There was not a shadow of doubt in Goodsir's mind as to the teachings of science guiding man to the borders of a higher region, and the standard, which he held aloft, was inscribed Divine Revelation, and no surrender.

Holding himself to be a guardian of his pupils, and showing a kindly interest in their well-doing, his teachings imperceptibly diffused a beneficial influence over the great majority of them, and in other walks than the strictly anatomical. He possessed the faculty of inspiring others with his own enthusiastic love of

science; hence the good results attending his precept and example. Previous to Goodsir's time in the University, few medical students had formed a taste for biological science beyond the requirements of physiology to illustrate the theory and practice of their art. He awakened a new feeling by making his anatomical teachings broader and more comprehensive, by a constant recurrence to comparative anatomy, and so gave a direction zoological-wards to numerous graduates of the University. A great change was wrought in this respect; before the year 1850, "Theses" on anatomical subjects were rare, if not exceptional, but after Goodsir's system of tuition came into operation, they ranked with the more common themes. His favourite pupils obtained either honorary distinction, or the gold medals awarded by the University for the best Theses; and many were no doubt led by his encouragement to make a position in the world of medicine. A few of his pupils imbibed his natural-history feeling, and pursued zoology with great enthusiasm. In proof of his success in imbuing his pupils with that love of science that marked his own career as teacher and museum conservator, it may be noted that no less than four of his young assistants obtained appointments in the Hunterian Museum of the Royal College of Surgeons, London—viz. Hallett, Lizars, Drummond, and Pettigrew. Goodsir was in the habit of altering his systematic course of lectures each year. Unlike other teachers, he could not go over the same ground two

years in succession, and so spare his energies; but always sought for a new exposition of the matter on hand; this variety had a refreshing effect upon those who attended two courses in succession.

He commenced his first winter session, 1846-47, with a class of 275 students, which number gradually increased, so that in 1852-53 (the year before his illness obliged him to go abroad) it numbered 368. On his return the numbers were somewhat diminished, but in 1860-61 it had reached 354 students; about a similar number would be enrolled by the second Monro at the dawn of the century; whilst Dr. Knox had one year the unrivalled class of 504.

In 1845, when demonstrator of anatomy, he intimated that he had "A System of Dissections" in the press. This promised work was to form a "Dissecting Manual," to be issued in parts, and with plans or simple outline drawings as guides in each stage of dissection, the whole to form a progressive series of studies for the Practical Rooms. Several years elapsed before he made a start, and then only to the extent of a few pages and no more. To issue a work entitled "*Studia Zoonomica*, by Members of the Anatomical Establishment of the University of Edinburgh," was one of his projects for stimulating the *ardor scientiæ* of those around him in 1860; it was among the last efforts of his fertile brain to exalt the character of his class and the fame of his University.

The more intelligent members of the anatomical class have always spoken in exaltation of the philoso-

phic teachings of the professor, and maintained that his published writings afforded no clue to his oral teaching, and the beneficent operations of his own mind over those of his audience. His lectures were like finished work from a master's hand; it was an intellectual treat to see the building up from day to day of a beautiful scientific structure upon an anatomical basis. His teaching, like true art, embellished and adorned his work; and of the youths who crowded in hundreds to his anatomical fane, not a fractional part of their numbers found fault with his ministrations; whilst the large majority seem to have been inspired by the constancy of purpose and love of science that possessed the Goodsir breast.

The dissecting-table was Goodsir's place; there he impersonated the diligent inquirer and true learner. After a full demonstration of a region, he kept turning over the parts of the anatomy as if the very handling of them would respond to his interrogations of nature. His head and hands always worked together. When his mind was absorbed in close investigation, nothing disturbed him—like Laennec at the bedside of a patient diagnosing the delicate *bruit* or *râle,* despite the crowds of students and the noise of *sabots* along the brick floors of the hospital-wards. No one knew human myology better than Goodsir; yet in 1841 he solicited the writer to get him an adult male for the purpose of making a complete dissection of the muscles, so as to study the functions and relations of these to surgery and comparative anatomy. As lately as the

autumn of 1858 he dissected a fine muscular subject,* and took casts of the different layers; these casts are in the anatomical museum, and constitute a complete series. Thus he continued a student through life, even of forms considered of commonplace note in the economy; to him, however, the muscles were viewed as capable of a higher interpretation than had hitherto been assigned them. In showing a strong bent in some directions, it implied no narrowed ground or belief; special structures were but the starting-points to the occupancy of a larger field of investigation, and the attainment of a broader generalisation in his science. He loved his art for his art's sake, and longed to apply his science for the science and the truth's sake.

Brought up to physic from his teens, and being early initiated in its practical departments, he all along desired to be engaged in the active pursuit of his profession; and as his own powers were enlarged and strengthened, John Hunter, the anatomist and surgeon, became more and more his ideal and historic example. In his letters, in his conversation, and not less in his anatomical teachings, there was a clear declaration in favour of practice as the aim and purport of medical

* This subject, the body of an Edinburgh carter of intensely whisky habits, who, in a drunken state, fell from his cart and died on the spot, remained free from decomposition during thirty days of a hot August! Goodsir was much struck with the fact, considering the mode of death of the person. Had the whisky taken during life proved an antiseptic *post mortem?* The case is interesting in connection with the detection of free alcohol in the brain of drunkards by Dr. John Percy (Graduation Thesis, Edinburgh 1838), now the distinguished Professor of Metallurgy at the School of Mines, Jermyn Street, London.

education. In the spring of 1843, addressing his brother Harry, then pushing forward in science beyond most persons of his age, he admonishes him not to overlook practice; for though one man only, as far as he knew (John Hunter), ever combined science and practice, it was to be done by self-command and early rising—the latter being a *sine qua non* to eminence in scientific medicine. He pointed to Dr. Abercrombie of Edinburgh—"a perfect clock, as rich as a Jew, and a great physician besides." During this year he talked of a house in the New Town for practice purely; and in 1847, when he took up his residence in George Square, he did not hide his aspirations to become a consulting surgeon. He viewed practice in its broadest relations as a means of research, and of greater or more immediate usefulness as a co-operator with science, joining with it a complete circle of medical training which it behoved a teacher in high position like himself to expound and inculcate. He believed that anatomy, physiology, and pathology could never be advanced in a proper way without the daily consideration and treatment of disease. Referring to personal considerations in 1843, he thought that the Goodsir family of doctors, having been eighty years in the east of Fife, should be transplanted, and that his brothers Harry and Archie should settle down with himself in Edinburgh, where they would form a "formidable trio."

After these hopes of family centralisation had vanished, Goodsir was no less desirous for his favourite conjunction—the teaching of science illustrated by

practice. As few professors in the Scotch universities have private means apart from the emoluments of office to carry on scientific pursuits efficiently, Goodsir's adhesion to practice was of twofold aim. To uphold the chair of anatomy as he began and carried on its management from first to last was exceedingly heavy upon his purse, and as the wider range of scientific research could only be accomplished by an addition to his income, he wished to strengthen his hands by other professional means. Practice also, by withdrawing him from too rigid a pursuit of science, would have been a healthful and useful relaxation of the highest import. Above all other considerations, however, in his eyes was the command of wards in a surgical hospital to enable him to illustrate his professorial teaching, and to make it more largely efficient and beneficial to the interests of his class. With these established data in his mind he applied for the first vacancy of assistant-surgeon in the Royal Infirmary of Edinburgh* in 1848, but unluckily did not obtain it. He was much disappointed, and so expressed himself to the managers of the institution, whom he believed to have acted on a foregone conclusion rather than on the merits of the applicants. An obstacle had been thrown in his way when, as he thought, there was room for all the labourers in the field, if a true generosity and foresightedness for ultimate good had prevailed in the decisions of the governing body. The

* He became a Fellow of the Royal College of Surgeons this year (1848), in all probability to provide himself with the needful qualification of hospital surgeon to the Royal Infirmary.

Goodsir medical inheritance of eighty years, the John Hunter ideal, or that of Monro *secundus*, his personal ambition to become a great surgeon, the good and advancement of the medical school, and all the cherished hopes of a large and exultant promise, were scattered to the winds by this refusal of his services in an institution that he could not have failed to benefit. Sensitive to a degree, he keenly felt what appeared to him to have arisen from a narrow-minded opposition, and from that day eschewed all relations with the Edinburgh Infirmary.

In 1848 Goodsir became a member of the Highland and Agricultural Society, and for many years acted as chairman of the veterinary department, and assisted at the annual examination of Professor Dick's pupils for the veterinary surgeon's diploma. He used to be frequently consulted on strictly agricultural matters; thus the Marquis of Tweeddale (June 1855) wished his opinion on the feeding qualities of turnips that were known to contain 90 per cent of water in their composition. The Marquis had drawn off 25 per cent of the water, and found that cattle ate the turnips with the same relish. Goodsir, viewing the turnips as artificial food—grass being the natural aliment of the ox—advised, as Flourens' experiments in feeding sheep with carrots reduced to a fine pulp indicated, the crushing of the turnip into a pulp, in the expectation that it would pass to the third or fourth stomach and save the chewing of the cud. The water he did not object to, as it might be necessary for the economy of

the animal. He had studied the horse as carefully as any veterinary surgeon, and rejoiced in a fine animal, such as the Arabian he got from the Duke of Hamilton and petted for years. Speaking of horses one day to Mr. Turner, he said—"I love the horse; I love the horse,"—laying great stress on the word *love*, and then added without any pause—"I've dissected him twice." It was a new mode of showing love for a beast, and the remark on this head was a genuine Goodsirian declaration. In March 1849 he presented a cast of the dissection of a horse to the Royal Institution in Edinburgh, and received the thanks of the directors for a work "executed with so much spirit, and capable of being of so much value anatomically to students." His last appearance, in 1866, as president of the annual examination of the candidates for the veterinary diploma was a terrible effort, and each night he returned home quite exhausted; and this ended in one of his most severe attacks and a prostration of strength for weeks.

CHAPTER VIII.

Zoological Studies — Lectures on Comparative Anatomy — Knox's Opinions—The Æsthetic Club—Defence of Anatomy—Lectures for Jameson—Ill Health—On the Continent—Joints—Nerves.

ZOOLOGY as a science seems to have found but few cultivators in Britain after the death of John Hunter, or they were non-demonstrative of their labours, seeing that, with the exception of Yarrell, Macgillivray, and others in special walks, the fourth decade had dawned before the general works of Professors Grant and Rymer Jones on comparative anatomy were published in England. France was rich in her Daubentons, Cuviers, and St. Hilaires; and Germany ranked with France in the number of her monographs and periodicals devoted to natural history. England had been more disposed to look at anatomy as a means to an end—medical practice—than as a science in its broader philosophical relations. Goodsir may be said to have started with the fresh start, and grown up with the strong growth of comparative anatomy; he appeared at a time when individual effort could readily assert its claims, and when there was a dearth of workers in a country rich in opportunities—rich in seas, rivers, and unquarried palæontology. His early love for zoology never waned, but rather increased with ad-

vancing years. In Fife, fishes and molluscs engaged a good deal of his attention; in Edinburgh, his zoological studies were as widely divergent as the extremes of monads and monkeys. In the midst of this variety, however, the Knox indoctrination became visible in his investigations of the *Cetacea, Salmonidæ,* and *Clupeidæ,* of which there were abundant supplies in the Scottish seas and estuaries. At one time Goodsir talked of writing a monograph on the Cetacea, and this idea was entertained on the Continent, as the naturalists of northern Europe frequently interrogated him on the history and structure of these mammals. If the Cetacea, *inter alia,* engaged the earlier years of his professorship, electrical fishes came to be of greater import to him in his meridian. He spared neither money nor pains to obtain these rarer treasures, and as his pupils were scattered over the globe he obtained many specimens, though frequently at great expense.

A knowledge of comparative anatomy was a great desideratum with Goodsir, who aspired to rank with Hunter of the past and Owen of the present day; besides its practical application in furnishing variety and colouring to his systematic course of lectures. Having no sympathy with the artificial aids to memory, or what was styled popular teaching by diagrams, as often incorrect as misleading, when trusted to *per se,* he sought the higher ground of comparative anatomy and physiology as adjuvantia to his prelections. Human osteology studied alongside that of the higher mammalia, extant or fossilized, became of deep interest

to a class. Goodsir had large resources of his own, and these, strengthened by his acquaintance with the researches of Owen, Hugh Falconer, and others, were of infinite service to him in his practical teachings and illustrations.

In the summer of 1847 Goodsir delivered a series of systematic lectures on the comparative anatomy of the Invertebrata, in which he expounded the leading facts and principles then known, and tested and compared them with what he himself had observed over a wide field of zoological inquiry. These lectures were carefully transcribed by Mr. C. H. Hallett, one of his assistants, and intended for publication, but in seeking for a high standard of excellence in the particular work in which he was then engaged, as in every department of science, and being pressed by more varied work, the manuscript never reached the printer's hands. It may not, perhaps, be considered out of place in this memoir to give a short summary of some of his views taken from the MS. copy now before the writer; it will serve to indicate the general tenor of his observations.

Sponges.—He described the animal matter of sponges as composed of innumerable amæbæ, which being unable to support themselves require organs of support, or, in other words, a skeleton, which may be either bony, siliceous, or calcareous.

Echinodermata.—His lectures on the *Echinodermata* were of a very complete character, and illustrated by numerous dissected specimens prepared

under his superintendence, and which now constitute part of the comparative anatomy collection of the University of Edinburgh. He was particularly successful in his injections of the water-vascular system of those animals, specimens of which he exhibited to the Wernerian Society in 1846, and was led therefrom to agree with those authorities who considered that the vascular and water-vascular systems were not distinct and independent, but parts of one great vascular system connected together into one system by communications. For he found that when an injection was forced into the water-vascular system of tubes, it did not confine itself to them, but passed into and distended the other systems also without any rupture of vessels. He believed that in the sea-urchins, the blood moved in various directions without any regular current, and that the direction was influenced by circumstances. For these animals have several series of ambulacral holes and protrusible feet, and his injections of the system of vessels provided for the protrusion of the feet, displayed fine vessels passing along each ambulacral segment which did not pass directly into the inner part of the suckers, but first subdivided into a double series of triangular laminæ, or vascular plates arranged on each side of the ambulacral holes. These vascular laminæ contain a very rich network of vessels, from which the feet procure the fluid by which they were distended in the injections.

He described, with great care, from observations

made on the living animal, the respiratory movements in *Holothuriæ.* Suppose the animal desires to take in a quantity of water, it first contracts the anterior end of its body, and then forces all the water it may contain into the posterior end, which now bulges outwards. A fixed point for the action of the numerous small muscles which pass between the outer surface of the cloaca and inner surface of the fleshy envelope of the animal is thus provided; these muscles then contract and distend the cloaca. The sphincter fibres surrounding the anus then relax, and the sea-water rushing through the opening completely fills the cloaca. Then the anus firmly closes, and at the same time the aperture of the intestinal canal is shut. The muscular wall of the cloaca then contracts, and presses the water into the respiratory tree through the aperture at each side of the terminal part of the intestinal canal. The animal respires, when active, four or five times in a minute. He described also the existence in *Holothuriæ* of a twisted calcareous tube close to the tube which conveys away the secretion of the genital organs; this he regarded as homologous with the jointed tube which, in the star-fishes, connects the madreporiform tubercle with the water-ring.

Distoma.—In his account of the anatomy of *Distoma hepatica,* he considered, contrary to the opinion generally held by anatomists, that it contained a cavity in its interior like the cavity of the *Holothuriadæ,* in which the viscera of distoma were situated.

He gave a careful description of that curious para-

site which infests the nervous system of the haddock and the cod, but as his views on the structure of this animal appear in vol. ii. p. 497, it is unnecessary to dwell upon them here. In his account of the *Trichina spiralis,* he states that from the winter of 1843 to the date of his lecture in 1847, no subject infested by this parasite had been received into the anatomical rooms of the University, curiously contrasting with the frequency noticed of late years in Germany.

In his lectures on the annelids, insects, and crustacea, he argued that the dorsal vessel of these animals is homologous not with the aortic trunk of the *Vertebrata* lying beneath the spine, but with the heart and primitive aorta.

His lectures on the tunicated molluscs were illustrated by many beautiful dissections, some of which had been exhibited to the Wernerian Society in January 1841. As the tunic of *Phallusia vulgaris* possessed so many vessels, it was found, on injection, to assume a bright vermilion tint. He had succeeded in injecting both the vein and artery which enter the outer tunic of the animal, and had recognised a free and frequent anastomosis in its substance. Where this outer tunic was adherent to any object, it gave off, as it were, numerous processes or prolongations, which projected from the general surface, and in these the ramifications and anastomoses of the blood-vessels were most numerous. Hence this tunic was to be regarded as something more than a mere cuticle.

From time to time Knox corresponded with Goodsir on scientific subjects; and in October 1845, being asked to translate M. De Blainville's work on the *Vertebrata,* solicited his old pupil to join him in issuing a quarterly fasciculus based on the text of the French professor, and incorporating the latest British discoveries in anatomical science. Nothing came of the proposal. In December 1852 Knox presented a copy of his *Manual of Anatomy* to Goodsir, who acknowledged the pleasure he had in reading it, and added—"I have been astonished to find how much of what I have been in the habit of conceiving as peculiar to my own course of lectures I had derived long ago from you. I assure you I have always been deeply grateful to you as my teacher, and I have always, in public as well as in private, expressed myself to this effect, and shall not less continue to do so henceforward. I have strongly recommended your book to my pupils." Knox considered Goodsir to be his most distinguished pupil* in anatomy, and naturally attached great value to his opinions on anatomical subjects.

An Æsthetic Club was established in Edinburgh in 1851; its chief promoters were Professors Kelland and Goodsir, Messrs. D. R. Hay and James Ballantine, and it included Professors J. Y. Simpson, Laycock, and Piazzi Smyth, and also Dr. John Brown (*Rab*

* Knox, in his application for the Chair of Physiology in Edinburgh (1841), begged the attention of the patrons to the following list of distinguished pupils whom he had educated :—"R. Boyd, W. Fergusson, T. W. Jones, John and Harry Goodsir, Henry Lonsdale, John Reid, J. H. Balfour, James Duncan, Douglas Maclagan, Patrick Newbigging, John H. Bennett, etc."

and his Friends), E. S. Dallas (author of *The Gay Science*), Sheriff Gordon, and four or five artists of distinction. The number of the club was limited to twenty, and its members met at each other's houses once a-month to discuss their subjects and to enjoy an æsthetic symposium with Scotch tipple. Goodsir read two papers "On the Natural Principles of Beauty," based on D. R. Hay's work—"Geometric Beauty of the Human Figure."* These essays must have been pleasantly viewed by the author, judging from the fact that they were printed wholly or in part; but, for reasons best known to himself, he would not, though earnestly solicited by the club, consent to their publication. It is to be regretted that he destroyed these papers, which had cost him so much thought and no less labour to develop by both pen and pencil. Among other contributions was one "On Actual and Relative Beauty," which Mr. Hay read in his absence at Mr. Ballantine's house; this was also in a complete form, and considered a worthy effort. He read several other papers—*e. g.* "The Æsthetics of Smell," and an "Inquiry into the General Principle which regulates the Approbation or Disapprobation of Sounds;" occasionally his work occupied two nights' discussion, so that he appears to have been one of the most prominent members of the club.

* D. R. Hay owed a great deal to Goodsir. Devoid of anatomical knowedge, Hay could not have carried out the principles of his theory to a legitimate issue without the aid of an anatomist, and one imbued with large æsthetic vision. Goodsir fulfilled these indications, and not only helped the purport as well, but furnished the anatomical details for Mr. Hay's remarkable book.

His essay "On the Æsthetics of the Ugly"—the most remarkable of all his contributions—was read in the spring of 1853, and occupied two evenings. In treating of the ugly, his æsthetic survey embraced various types and forms in nature, also the senses of smell, vision, and taste, as well as the physical ugliness to be met with in man and brute. This striking title—Æsthetics of the Ugly—curiously enough had been adopted the same year by Carl Rosenfranz in his work—*Aesthetik Des Hässlichen*—published at Königsberg in 1853. In many respects the views of the Scot and German agreed, the work of the latter being an amplification, or rather a treatise on the subject, whilst the former had only glanced at the general theory. Goodsir, like all men of true æsthetic feeling, would readily mark any deviation from his æsthetic standard, such as the inconsonant sounds, the anormal lines, and every questionable antagonism to a thing of beauty being a joy for ever. All living things he held to be more or less beautiful if looked upon in a proper light. Thus the "ugly and venomous toad," as the poet called it in respect to the popular dread, was in his eyes, as in those of all men of cultivated taste, the most beautiful of creatures, not as observed on the table of the anatomist or in confined artificial areas, but seen in its natural *habitat* on the grassy margin of a pond, in close proximity to the grey lichened stones, or under the umbrageous greenwood tree; there the animal could be viewed in its true æsthetic relations, and specifically marked in high relief, with eyes

resplendent—nay, more brilliant than diamond surface or stones of ruby.

The death of D. R. Hay and the retirement of Goodsir materially affected the interests of the Æsthetic Club; it no longer exists. It may be mentioned here that Mr. Hay, wishing to show his high appreciation of Professor Goodsir's aid and counsel in many directions, presented him with Dyce's Cartoon of the Judgment of Solomon. Looking upon the cartoon as calculated to foster a love of art among students, Professor Goodsir, soon after Mr. Hay's death, offered it for the acceptance of the Royal Scottish Academy, who evidently prized the gift, and gave it a place on the walls of the Royal Institution, Edinburgh.

Late in the autumn of 1852 some of the leading minds in Edinburgh established an association for the removal of "Professional Tests in the Lay Chairs of Scottish Universities." The religious community took alarm at this charitable proposal, and one of its bigoted members wrote a furious letter to *The Edinburgh Evening Post and Scottish Record*, concluding his argument for the continuance of the most rigid tests by stating that "no infidel could desire a better channel for the insinuation of scepticism than the class-room of moral philosophy, or the lecture-room of anatomy." This was a strong dose of ruffianism for any man to bear, and must have been very galling to the professor of anatomy, who had proved a severe religious orthodoxy for six years in his chair, and all his life stuck to the backbone of Calvinism. He took up his pen in

defenee of anatomy as a seienee that had afforded the most numerous and the most satisfaetory arguments in natural theology; "that knowledge or rudiment of knowledge, eoneerning God, which may be obtained by eontemplation of his ereatures." The anatomist, "lingering amid the harmonies of law and symmetry, eonstancy and development," as Goodsir said, "takes his part freely in the religious hymn in honour of the Creator, to whieh Galen so gladly lent his voiee, and in whieh the best physiologists of sueeeeding times have ever joined." That among anatomists there would be differenees of opinion he admitted freely, "but that anatomists, from any peeuliarity of their science, should be less suseeptive of religious eonvietion, and more opposed than their scientifie brethren to the Christian faith," appeared to Goodsir "an unfounded and most hurtful prejudiee."

Owing to the failing health of his eolleague, Professor Jameson, Goodsir was indueed to deliver the eourse of leetures on natural history during the summer session of 1853. This eourse, which was mainly zoologieal, was prefaeed by a series of leetures on what he termed "General Zoology," the eomprehensive nature of whieh may be gathered from the following titles:—

1. On the psyehologieal eondition of the Brute as eontrasted with that of Man.

2. On the condition of Human Thought; or Pereeption, Conception, Language, Logie, and Seienee.

3. On the condition of Animal and Human Life.

4. On the characters of Organised and Inorganised Bodies, and on the general arrangements, structures, and uses of the Textures and Organs.

5. On the Principles of Classification and Geographical Distribution.

Wearied with the heavy labours of a long winter's session that had just terminated, and having his usual summer course on anatomy to look to daily, there was no professor in the University so unfortunately circumstanced as to time, labour, and health; yet he made no demur to his colleague's wish, and offered no claim of exemption from so large a responsibility as the conducting of the natural history chair for three months. Though his own health was manifestly impaired, he could not bear to see Jameson's class in abeyance; moreover, he looked with a Wellingtonian spirit to the "carrying on" of the medical department of the Edinburgh University in all its entirety. He would not read Jameson's lectures, or be content to illustrate his notes to the class, as everybody but himself would have done, acting as a *locum tenens*, but struck out a path of his own altogether independent and free.

The course was strictly Goodsir's. The lectures were original in character and in force, and the treatment of the whole subject strikingly novel. They excited large attention in the University, at that time rich in numbers of good students, many of whom raised themselves to eminence both at home and abroad.

The men of this period were lavish in their admiration of the anatomical professor, whose lectures not only created an exaltation of feeling that pervaded the whole school, but are still spoken of among the *memorabilia* of the University in the last decade. All his energies were brought into play to render this course of lectures worthy of himself and the high position he occupied. Every *alumnus* could see in the shaky limbs and pallid visage the overtaxed man of labour struggling with giant efforts to carry on a special class, and to conduct it in a special way; for Goodsir's zoological views were presented to the observer as so many facets—new, well-defined, and prismatic.

On referring to the titles of these lectures, it will be seen that he had taken a wide and comprehensive ground for illustration. It was not anatomy, not zoology *per se*, or as embracing principles of classification, but the psychological conditions of man as compared with the brute, and the highest exercise of the human faculties—perception, logic, and science. Here he was touching the heels of the metaphysician—only, however, as collateral to the strictly physiological and psychological. The Scotch pupils, cautioned by their kirk against the scepticism of science in general, and of anatomical teachers in particular, were struck with the pious exhortations of the professor as much as the whole class was delighted with the zoological course, illustrating his fine acumen, individuality, and broad generalisations. These lectures cost him an infinite amount of thought and labour, and at the end of the course he

was shrunk in features, worn in body, shattered in nerves, and almost a helpless invalid. Professor Edward Forbes, on his deathbed, said the Bailies of of Edinburgh, in forcing him to lecture immediately on his appointment to Jameson's Chair, had killed the goose that laid the golden eggs; and under circumstances almost as pressing and destructive of health, Goodsir, occupying the same chair *pro tempore*, was sacrificed beyond the power of restoration.

At no time was Goodsir so strong in health as he appeared; he suffered from cynanche tonsillaris, dyspepsia, boils, and impaired strength caused by incessant labour and neglect of the most common hygiène. On one of his summer visits to the writer in 1850, and after spending a day in examining the estuary of the Solway, he felt numbness and coldness of the extremities and general depression. This seems to have been the earliest manifestation of his disease. As years rolled on, the movements of his lower limbs were visibly affected; there was occasional stumbling, difficulty of going down stairs, and want of power in balancing himself, especially in the dark, when his eyes had nothing to rest upon. Now and then he suffered from neuralgia. These physical ailments were increased by any mental disturbance, and troubles of all kinds induced great irritability of manner and feeling. He persisted in work, and spurned every friendly advice till 1853, when he himself came to recognise the need of rest and a sojourn on the Continent. In August of that year he went to Wildbad in the Black Forest, and placed himself under the care

of Dr. Fallati. In September a consultation was held on his case by Dr. Fallati, Dr. Spiess of Frankfort-on-the-Maine, and Professor Baum of Göttingen, and Goodsir was recommended to spend the winter at Nice; there he remained till May 1854 under the care of Dr. Travis. He again returned to Wildbad, to the use of the baths, and an occasional cupping over the loins. His case was viewed by his Continental friends as an incipient paralysis of the inferior extremities, originating in overwork of body and mind, and demanding absolute rest. In the autumn Goodsir returned home in better spirits.

During his year's absence it was arranged that Dr. John Struthers, then the extra-mural lecturer on anatomy, now professor of that subject in Aberdeen, should have the management of the class, which he conducted so well as to claim from Mr. Goodsir on his return the expression of his high satisfaction.

Of those who hoped, and hoped so long in vain, for the return of the Franklin expedition that left the shores of England in the summer of 1845, none were so sanguine as Lady Franklin, the noble-minded and affectionate wife of the master mind of the exploring party, and Professor John Goodsir. It was 1854 before Goodsir could realise the untimely fate of a long-looked-for brother, whose life, if spared, would have been so precious to science. Dr. Martin Barry, with true consideration, wrote (October 25, 1854), from Beccles in Suffolk, the following letter:—"I beg to offer my friend Professor Goodsir a line of deep condolence.

For however preferable decisive intelligence may be to never-ending suspense, I well know that the relief must be dearly bought when obtained by means that unmistakably connect long-continued sufferings with the last days of a brother! M. Barry."

If Goodsir's fondness for mechanics was a leading feature in his youth, and aided him in the practice of surgery, his general knowledge of physics served him a good purpose in elucidating the operations and functions of the structures which enter into the formation of joints. Next in import to his labours in the field of cellular physiology and pathology, and of morphology, was his study of geometry applied to anatomy or natural organisms. His papers on the mechanism of the joints, one of which was read to the Royal Society of Edinburgh, got him great *éclat*, as they were viewed as highly successful efforts, even admitting their basis as resting on the antecedent labours of the Webers and Meyer. Goodsir maintained that the articular surface at the end of a bone, although a continuous surface, is yet subdivided into distinct areas and facets, and that each facet performs its proper part in the movements of the joint; thus, in the movement of extension, corresponding facets on opposite articular surfaces are in apposition, whilst in the movement of flexion these surfaces may be widely separate, and other facets are brought into play or contact with each other. No better notion of this could be given than in his description of the patella. He also pointed out that the folds of the synovial

membrane enclosing fat, so frequently met with in the joints, act "as movable stuffing pads which not only smear the synovia over the opposite cartilaginous surface, but steady the movements of the joints by passing into the spaces left between the surfaces during action." Another notion of Goodsir's was that the movements of the joints were of a spiral character. In the knee-joint, to which he devoted much attention, he regarded the combined gliding and rolling movements of flexion and extension, as performed between two conical double-threaded screw-combinations, an anterior and a posterior—the anterior being a left-handed screw, and the posterior a right-handed screw in the right knee-joint; the anterior a right-handed and the posterior a left-handed screw in the left knee-joint. He acknowledged his obligations to Meyer's labours, and gave a larger interpretation to the anatomy and mechanism of the joints than the German had done, and showed that the history of these important structures still afforded abundant room for inquiry.

The numerous interesting observations made by H. Müller, Corti, Kölliker, Rudolf, Wagner, and others, a good many years ago, on the termination of the nerves both peripherally and centrally,* the discovery of the

* The writer may be pardoned for alluding to his own observations in the same direction, and his discovery of the loop-like termination of the nerve-fibres, medullary and cerebral. Vide *Edinburgh Medical and Surgical Journal*, vol. 60 p. 324, October 1843 (Dr. Lonsdale's "History of a Case of Monstrosity"), where will be found a general reference to the labours of the French and German anatomists who had investigated the minute anatomy of the nerve-structures.

peculiar bodies in the retina and cochlea, and the relations of the nerve-fibres to the nerve-cells, early attracted his attention. He repeated these investigations, and held that nerve filaments are provided both centripetally and peripherally with current exciting structures, by means of which alone their functional currents can be initiated.

CHAPTER IX.

Morphology—Goethe and Others—Goodsir's Views and Influences—The Anatomical Museum—Social Reforms—Death of Forbes—Holidays—Philosophical Apparatus.

Jean Jacques Rousseau, so exuberant in sentimentality, had also a vein of true philosophy in his composition. His diligence in the field made him a botanical discoverer; and this, conjoined with his closet studies, afforded him "a glimpse of those transformations which hide under multiple forms the more simple forms from which they are derived." If Lavater and Zimmerman enticed Goethe from poesy to nature, the writings of "Jean Jacques" gave him the text to a new philosophy—vegetable morphology. Under Loder of Jena Goethe took to the study of anatomy; and the picking up a sheep's cranium led him to infer the existence of an intermaxillary bone in the human skull—an idea probably present to the mind of Caspar Friedrich Wolff, if not Vesalius and Winslow—of great import in the study of the vertebrate head. Guided by his belief in the unity of organic composition, or the existence of an anatomical type according to which organised beings may be said to be constructed, Goethe laid the foundation of animal morphology as far back as 1791, but did not then

publish his opinions. In his general introduction to *Comparative Anatomy founded on Osteology,* he proposed "to establish an anatomical type, a sort of universal image, representing, as far as possible, the bones of all animals, to serve as a circle for describing them according to an order previously established;" and he carried out his views by a laborious comparison of each piece in the series of adult animals. Somewhat similar ideas originated independently in the mind of Oken, who published his views in his celebrated "Programm" in 1807. Bojanus, Spix, and Carus, then followed in the same direction; and this branch of general osteology has been successfully pursued by Meckel, Cuvier, Geoffroy St. Hilaire, Owen, and Huxley. The morphological aspect which Goodsir viewed as the complement of the chemico-physical in the pursuit of anatomical science, has been indirectly advanced by Pander, Von Baer, Rathke, Johannes Müller, Wagner, Reichert, and Bischoff, who, by the investigation of the development of the embryo in man and animals, have evolved a series of morphological laws, which constitute the basis of the morphological department or aspect of organic science. The anatomical methods adopted by G. St. Hilaire in France appeared to Goodsir as fantastic and fruitless as those of Oken; but, in the feud between St. Hilaire and Cuvier respecting their methods of anatomical research, the co-ordinate importance of the doctrine of final causes and the doctrine of type was established. By the combinations of the teleological

and sound morphological methods the present French school of zoology and comparative anatomy has attained that high reputation which it owes to the labours of Audouin, Milne Edwards, and their pupils.

When Sir David Brewster was preparing a review of the "Scientific Biography of Goethe," for the *North British Review*, February 1864, he applied to Professor Goodsir for his opinion of the German, and for an estimate of the value set by Modern Anatomists on Goethe's speculations on Comparative Anatomy and Osteology. Goodsir, always ready to aid his friends, went carefully over Goethe's work, and compared it with that done by his own countrymen as well as his French contemporaries, and thus was enabled to furnish Sir David with a *resumé* of Goethe's history, *quoad* Science and Morphology. Goodsir's estimate of Goethe is ingeniously woven into Sir David's review, but the source from which Sir David derived his morphological ideas was not acknowledged in the course of the article.

Goodsir, whose early love for morphology has been noticed in preceding chapters, kept his eyes open to every new datum furnished to the science; and all along seems to have had a desire to emulate Richard Owen, whom he esteemed more highly than any other British authority as a teleologist and comparative anatomist.

On referring to his essay "On the Morphological Relations of the Nervous System" (vol. ii. art. v.), it will be seen that Goodsir viewed the inquiry as demanding "constant reference to the series of embryo as well

as of adult forms;" that "the morphology of any one organic system in the annulose or vertebrate animal cannot be safely or satisfactorily investigated without constant reference to the others," on the ground "that all the organic systems are dependent on one another in the constitution of the organism." He further showed that in morphological inquiries into the skeleton, the relations which the vascular and nervous systems bore to the osseous had to be considered, and that those relations aided the inquirer materially in arriving at a proper conception of the morphology of the part. It was in the application of the above principles that he was led to infer that the upper limb was not an appendage of the head, but that its position was to be regarded as an appendage of the lower part of the neck, as it receives its nervous supply from that part of the spinal cord; and further, that the limb is not necessarily an appendage of a single segment of the body.

He was in favour of a "more extended and precise system of nomenclature for this department of the science," he offered a new terminology, and gave substantial reasons for its adoption. It may be said of his "sclerotome" that it is more comprehensive than the term "skeleton," and may be more conveniently applied, as it embraces a greater number of objects than the word skeleton. Professor Owen, with his characteristic good humour, chaffed Goodsir on his "syssoma*tomes*" being a trespass on the domain of the surgeon, who made use of the terminal syllable *tome* for some of his

instruments—*e.g.* litho*tome;* otherwise Owen thought, as others have done, speaking with authority, Goodsir's nomenclature unobjectionable.

His essay (vol. ii. art. vi.) "On the Morphological Constitution of the Skeleton of the Vertebrate Head" was read at the Cheltenham meeting of the British Association in 1856, and occupied three hours in delivery. It cannot be epitomised with advantage. Historical in its survey, highly elaborate in construction and detail, and exemplifying a fair criticism of the labours of his predecessors, it is characteristic of the man of great diligence, not without a German indoctrination. Whatever views may finally come to prevail on this subject of inquiry, and be Goodsir's hypothesis what it may, no anatomist of the future can possibly overlook the workings of a mind of such aptitude as the Edinburgh professor's for morphological investigation. Here and there, in discussing the alliances of morphology to the study of general organisms, Goodsir expresses his opinions with firmness; thus he denied on philosophical grounds that morphology and teleology are distinct in the sense that the latter principle provides for what the former is insufficient; he viewed them as "merely opposite, because, in the present phase of science, necessary anthropomorphic aspects of the same divine principle evinced in the laws of organisation." He could not give his assent to the hæmal arch of Professor Owen's osteological doctrine, and throughout this essay there is evidence of his differing in opinion from his London

contemporary, always manifested, however, in a spirit worthy of the honourable feeling that should govern men in scientific rivalry aiming at truth.

If the morphologists differ as to type and organic homologues, and occasionally land themselves in the regions of pure transcendentalism, it should not be overlooked that in the history of all science there are vicissitudes in its progress as fickle as the meteorological changes of an English atmosphere: that pluviose and electrical clouds precede the clearer sky, and that the pleasurable *Phœbus* of discovery comes *post nubila* of doubts, difficulties, and disappointments. The deep truths of morphology can only be reached by repeated and successive tentative efforts, each of which may possibly leave its residuum of error to be explained in the course of time. Faults of judgment or the errors of conception, so likely to arise in the study of a science so complex and extended as the laws of life and organisation, had better come forth with a modicum of truth, than that observers should be too rigid in waiting for the perfection of human thought, or the establishment of a Newtonian *Principia* in physiology. Professor Owen, in writing Goodsir in 1861, on this very subject of morphology that had engrossed both their minds, admitted with philosophic candour that his mistakes might constitute a good share, but he always felt that science would get on quicker if men would set forth their proceeds without being over careful of the personal effects of slight errors in observation.

Everybody admits the segmentation of the skull, but few agree as to the number of its segments or "cranial vertebræ;" whilst men of authoritative stamp, like Huxley, do not admit these segments to be vertebral in character. Goethe adopted six cranial vertebræ, Oken in 1807 only three, Bojanus in 1818 increased the number to four, G. St. Hilaire in 1824 admitted seven, while Carus in 1827 adopted Goethe's six. The prevailing opinion is said to be in favour of three vertebræ—the occipital, and the posterior and anterior sphenoidal, as forming the cranial part of the skull; Owen believes in a fourth—namely the nasal. Goodsir recognised seven sclerotomes or segments in the mammalian and crocodilian head; but only six in the other vertebrata. General concurrence in Goodsir's views need not be looked for, though it may probably be conceded that the theories he has advanced possess a suggestiveness of their own, and that in his endeavours to expound them he has called in the teachings of embryology, and sought through that channel to implant them on a scientific basis. It is something to be able to say that his work has not been without its influence on his own generation, both of the London and Edinburgh Schools, and that it cannot fail to receive attention in all the morphological speculations of the future.

Professor Cleland of Galway, one of Goodsir's most distinguished pupils, in his paper, "On the Relations of the Vomer, Ethmoid, and Intermaxillary Bones" (*Transactions of Royal Society*, London, 1861), says—

"To Goodsir I owe entirely my morphological training, nor am I less sensible of the advantages which I have enjoyed in being frequently indoctrinated by him in those great principles of morphology which he illustrated in his communication to the British Association in 1856." The Galway professor speaks of his Edinburgh teacher's "explicit morphological nomenclature"—*e.g.* "somatome," "sclerotome;" and further adds, "The only theory of the segmentation of the skull, as far as I know, in which the teachings of embryology have been taken into account, and been sought to be explained, is that of Professor Goodsir." In one of his interesting lectures published in the *Lancet* (September 5, 1863), Professor Huxley says of Goodsir—"In this country there has been another exception to the mere blind developments of the votaries of Oken; I allude to Professor Goodsir of Edinburgh, and the able young men who have risen from his training. He is the only man, so far as I know, either on the Continent or here, who has understood the value of that which took place between 1837 and 1840, or thereabouts, in Germany, and has endeavoured to correct the error of the mere Okenist line of speculation by the severe criteria of embryology."

Dr. Hugh Falconer (16th February 1857) wrote from London to Goodsir:—"I have been reading your papers on morphology, as given in the *Edinburgh Philosophical Journal*, with great interest, and have been much impressed with the force, logical precision, and closeness of the argument—cardinal virtues which

are not very shining in like cases in this part of Her Majesty's dominions." In October 1853 J. Victor Carus of Leipsic addressed Goodsir :—" I beg you to accept of my *System of Animal Morphology* as a token of my great esteem, which I long very much to expréss to you personally. As a great part of the anatomical facts on which it is found is collected either in England, or at least from English specimens, it is but a matter of gratitude that I lay the results now before you who contributed so kindly to enlarge my small collection."

Next to his love of teaching was the formation of a museum that should be second to none in Britain. When appointed curator of the anatomical collection of the University, his first effort was to separate the strictly teaching department from the general series; and in two years he had made such progress that he was able (in October 1845) to report—" The entire collection embodies the science as far as it extends, so that an individual studying the collection from the first to the last series may acquire a knowledge of the science from the structures themselves, instead of from books." Harry Goodsir, before leaving for the Arctic Regions, had presented the University with such specimens from his collection, in spirits, as were required for the series of Invertebrata, but the greatest number in the curator's hands at that time were the joint collection of himself and Edward Forbes. In addition to John Arthur* as an assistant, he had Mr. Melville (now

* John Arthur, the janitor of the Professor's, was a living presence in the Anatomical Rooms of the University. In early manhood he was a

professor of natural history at Galway), "to whose remarkable combined knowledge of zoology, comparative, human, and morbid anatomy, and powers of minute dissection," Goodsir wrote, "I am indebted for a majority of the finest dissections in the series." He concluded this report by saying that if the work was continued with the same energy as it had been during his two years of conservatorship, "the physiological series of the University Museum would be on a level with the Hunterian Galleries, which contain undoubtedly the most complete series of illustrations of organic structures in Europe." But the limited funds at the disposal of the authorities have prevented the fulfilment of these expectations.

patient of Liston's, and his observations of the work done in the Surgical Hospital impressed him with a love of anatomy. Engaged by Monro *tertius* as a class-porter about 1830, his usefulness in the rooms, and his persuasive method with the students, along with a proved ability of knowing how to do things, and how to get them done, gave him great influence, so that from 1836 to 1846 he was as much a notability as his master Monro. He was continued in office by Goodsir, with whom he remained till his death in 1860. With an intelligence and shrewdness that amounted to keen diplomacy, and great skill in anatomical work, he also possessed some of the strong lines of character that marked Goodsir, for whom he had an intense admiration. John's long and obliging services gave him authority in the anatomical department, so that in the Professor's absence he appeared to the student, as he himself wished, and occasionally claimed to be, the *alter ego* of Goodsir. As a memento of "Burke the resurrectionist," who was hanged for wholesale murders in Edinburgh, John carried a tobacco-pouch made of the tanned skin of the villain, to show the date of his connection with the Anatomical Rooms. In after years he could exhibit the gold watch presented to him by his admiring friends. Goodsir, requiring greater props each year, felt Arthur's death very much in 1860. Mr. Stirling, who had been engaged by Goodsir in 1855, as his assistant in the conservatorship of the Museum, soon got into the Professor's way, and was very highly esteemed by him; he is now engaged with Professor Turner, and has shown his great skill in the preparations of nervous structures, as well as in other departments of anatomical work.

The museum had long wanted supervision and improvement, as well as extension; and Goodsir had literally to create new departments in the collection. As showing the enthusiasm which guided him, he and two or three assistants were engaged in the museum two hours before breakfast when light permitted, then from 10 A.M. till 4 P.M., and again in the evenings for an hour or more. He also had the labours of his teaching and superintendence of the Practical Rooms during the session. With heart and soul in the work, he effected a complete regeneration of the museum. With the exception of the specimens furnished by the first and second Monros, the comparative anatomy collection is very much Goodsir's creation, being developed under his directing hand. His thorough training in all descriptions of anatomical work made him the most suitable person in Scotland for the new undertaking; and now the museum offers as fine specimens as any collection in Europe—not so extensive and varied as some, but, in its own special walk, almost unequalled. There is an entire series of the anatomy of the Echinodermata, and of the finest kind. The same may be said of the ascidian molluscs and whalebone class of preparations. The interest he took in the study of the electrical organs of fishes of different species will account for the numerous dissections of the torpedo, etc., and the excellent mode in which the batteries and minute nervous threads of other animals of the class are shown. The cuttle-fish was a favourite study of Goodsir's, and is demon-

strated in every part of its anatomy. His numerous preparations, injected or otherwise, of the alimentary canal, showing the various modifications in the structure of the digestive organs generally in the mammalia, are beautifully displayed. In exhibiting the nervous system of the Aplysia, and in his minute injections of the lungs of reptiles and the gills of fishes, he was highly successful. Upwards of a thousand specimens of comparative anatomy are strong evidence of the reality of his work.

In 1851 Goodsir meditated publishing a pamphlet headed :—"Proposals for the Establishment of Medical Fellowships, to be held by Graduates in Medicine, to act as Medical Tutors in the University of Edinburgh." And in 1852 he framed the principles of an "*Ecclesiastical, Theological, and Social Reform.*" His programme occupied several heads; the first was "Presbytery unfavourable to learning." He was not satisfied with the Scottish Universities, either in their preliminary training or the more finished instruction offered their *alumni*. He sought for a more genuine scholarship and higher mental discipline, in which the tutorial system should play a prominent part. Fellowships he thought should be established as rewards or endowments for winners in the race of every branch of learning. Though eager for his own science—medicine, and the interests of the university—he had a strong wish for reform in the ecclesiastical government of Scotland, and seems to have been imbued with the spirit of his grandfather in all matters theological.

He suggested a higher scholarship in the church, and a broader and more enlightened spirit of theological inquiry, resting upon the Bible rather than dogmatic standards.

It is curious to see how much education and theology engrossed his thoughts, along with science, from 1851 to 1853. Among his MSS. is the following, evidently meant for a title-page :—"The Education of the People, Training of the Clergy, and Revision of Public Worship; Three Subjects for Immediate Consideration by the Church of Scotland: A Letter to the Very Reverend the Moderator of the General Assembly, from a Non-official Member of the Kirk." He complained of the system of public worship, that the Scriptures were not read or expounded, that there was too much preaching, and that the prayers were too doctrinal.

In 1853 Goodsir revised the English translation as it passed through the press of a work by Dr. Hannover of Copenhagen—*On the Construction and Use of the Microscope.*

The death of his loving associate Edward Forbes, in November 1854, was a sore trial to Goodsir and many other friends; the loss of so noble a spirit was also a sad blow to the Edinburgh University. Considering the bonds of friendship, the joint labours of their earlier years, and other circumstances in their history, the public generally looked to Goodsir for a biography of his departed friend, for he was the best fitted to do justice to his memory. It is not necessary to allude to the circumstances which brought Dr.

George Wilson into the field as the biographer; but it is incumbent to state that Goodsir meant to write the life of Forbes, and that Mr. David Forbes, F.R.S., approved of his doing so. Goodsir was by no means pleased with Dr. Wilson's part in the matter, independent of the greater objection in his mind to a chemist *ex professo* being the biographer of a naturalist; and the recollection of Professor John Reid's life, treated from a theological quite as much as from a physiological point of view by Wilson, did not improve his feelings *quoad* the life of Forbes.

His holidays—however paradoxical or absurd it may appear to apply such a term to hard labour—were spent in working from 10 A.M. till 5 P.M. in the University Museum. In 1860—during the vacation from August till November—he laboured incessantly, and used to say to his assistant he was never so happy as when in the museum, and mentioned his special pleasure in working with Professor Hyrtl at Vienna, where there was no interference with his time or his thoughts. A holiday time was quite an incongruity with a man, like Goodsir, of large solicitude for the progress of his science—a science linked, as he viewed it, with the interests of his species as well as the groundwork of his own aspirations. To his vision knowledge was never "enough and to spare," but scanty, if not infinitesimal, compared with the wants of humanity and the aims of philosophy. Thus, in the autumn of 1853, when suffering from marked physical infirmities, and the more depressed feeling of banishment

from his chair, his museum, and his home, he could not refrain from study and intellectual work. Most men in his situation would have fallen into a *dolce far niente* life and repose; but with Goodsir to be idle was to be miserable; to stay the progress of the machine, were it only to oil and adjust the gearing, implied, to his impetuous march, arrestment of force, if not retrogression; and a stand-still was no better than moth and rust. He was at Wildbad, and as the language of the country was of high import to the literature of his science, he took to its study, engaged a teacher, and plodded away in his usual fashion so as to fathom all its bearings. The "Black Forest," whilst it lost in local and historical interest gained immeasurably more in his eyes as affording philological instruction; in other words his retirement to Wildbad was far from being an *hiatus* in his life, as he added greatly to his knowledge of the German language and literature.

He acted similarly at Nice, which he reached before Christmas 1853; there he studied Italian, to make himself familiar with the language that clothed the poesy of Dante, and conveyed to the world of modern science the researches of Matteucci and Secchi. Nice was most enjoyable to Goodsir. At his feet was the Mediterranean upon whose shores the fates of empires had been decided, and the chief events of the world were clustered—events probably of as great import in man's history as those attending the victories of Alexander, the bewitchery of Cleopatra, and the martyred

devotion of the Jew of Tarsus. The fact of his proximity to the Alps, and the cities of Genoa, Florence, and Rome, with all their classic associations, lent a charm to his pursuit of Italian literature.

Having imbibed a taste for travel, he journeyed to Berlin in August 1857, and professedly for a holiday of its kind. There he made a favourable acquaintance with Johannes Müller, that noble German and still nobler son of science, now no more; there also he formed a closer intimacy with Du Bois Reymond, who happily still lives to illuminate the chemico-electrical phenomena of organised bodies and other intricate paths of physiology. Goodsir had carried a fine specimen of *Malapterurus* for the benefit of his friend Du Bois Reymond's experimental investigations, in which he also took part, and a very pleasant intercourse sprang from this scientific fraternization. He had other specimens of the *Malapterurus* conveyed from Edinburgh to his Berlin friend, and in return for these complimentary attentions was put in the way of obtaining philosophical apparatus. His studies in the anatomical museums of Berlin that autumn were very constant or almost daily. His note-book, with every page filled (now before the writer), sufficiently testifies to the extended and careful observations of the osteological departments of the museum, and with special reference to his morphological studies—the gist of which had been laid before the British Association the year previously. A great number of his memoranda refer to ichthyology, and specially the Clupeidæ,

not overlooking the salient points of the general collection. All his visits to the Continent were made for the purpose of studying the great anatomical collections, and obtaining physiological apparatus; and all this gathering of knowledge in the great cities of Europe was to be made applicable to his own collection, hoping, as all enthusiasts do, to live to see his own work the best of its kind, and then to be able to cry "Excelsior."

His love for anatomical specimens was nearly as great as that of Professor Bereiss of Helmstadt of the last century, who had collected 131 of Lieberkühn's anatomical injections and other specimens, and viewed them as the greatest of treasures to be within his reach night and day. Had the products of Goodsir's thirty years' labour been gathered under one roof, the collection would have been the most valuable in Scotland, and not less historical than demonstrative of the advance of the science during the most stirring epochs in the annals of natural history and medicine. Moreover, it would have been a monument to his own art as significant as the great collection in Lincoln's Inn Fields, London, is to the genius and industry of John Hunter. It was obviously his wish, for a long time, to make the University Museum, of which he was curator, the adorned capital of the Goodsir column; and as the world spoke of the Hunterian collection in London, it might some day come to speak of the Goodsirian in Edinburgh. He carved part of his masonry out of old materials, and still more out of the unquarried rocks;

then he used finer chisels than his predecessors, and sought to enrich his architecture by fresh emblems and fresh treatment. With an artistic feeling for colour, an æsthetic taste, and a thorough love of work amounting almost to a sacred devotion, he not only did more single-handed than any man of his time in museum-formation, but in displaying the *sine qua non* of each preparation in hand gave an illustrative speciality to his work, as distinct as the colouring of Titian or the minute traits in the tavern-scenes of Teniers.

On his return from Germany, in 1857, he paid a visit to his friend Dr. Acland of Oxford, and enjoyed it exceedingly. He had an appreciating host in the Oxford Professor, with whom he could make a daily inspection of the new museum, then approaching completion, and fulfilling all the requirements of an Anatomical and Natural History collection. Goodsir liked to talk of the glorious past of that ancient university, its mediæval struggles, its historic characters and their defence of what appeared best in religion, politics, and letters. Oxford, with its classic fame, its scholastic influence, and its educational modes and purport, were a delight to Goodsir, who would gladly have tried to implant the Oxonian system upon the hard and dry northern scheme of education. For, with all his nationality and large inheritance of the Scottish covenanting spirit, he was too broad in his beliefs, and too zealous for freedom of thought, not to see the need of some qualifications to the doctrinal, dry, and dogmatic standards ruling the religious denominations, if not the

ethics and philosophical teaching of Scotland. Oxford had other charms in its fellowships and endowments, and its pleasant retreats for the aged literati, or those who had earned a philosophical status within its academic halls.

To render anatomical and physiological research worthy of its high calling, and consonant with his wonted mode of investigation, Goodsir saw the desirability of having the most perfect instruments to work with. The great minds of Europe, bent on similar inquiries as Goodsir, called in the aid of the philosophical instrument maker. He had frequently commissioned his pupils or friends visiting the Continent, to pick up all the novel apparatus applicable to anatomy and physiology; and in 1859, between the winter and summer sessions, he visited Paris solely for the purpose of obtaining philosophic apparatus. In the autumn of the same year, and for a similar object, he visited Leipsic, Dresden, and Vienna. He of course spent much time in the museums, and talked with all the men of eminence. He was greatly pleased with the city of Prague, and not least with what he saw in the dissecting rooms there, and which he considered worthy of being adopted at home. These frequent visits to the Continent enabled him to purchase a complete collection of physiological apparatus, such as had been employed by Du Bois Reymond, Vierordt, Pflüger, and Helmholtz, and other distinguished German physiologists. He was the first to introduce these very costly instruments to

Scotland, and for his own private research and instruction.

Foreign *savans* frequently consulted Goodsir on their special inquiries. When the Austrian Government, in 1857, decided on a scientific circumnavigation of the globe, Goodsir was applied to for information as to the best modes of dredging and other equipments for the natural history service of the expedition. Goodsir supplied the *Novarà* ship with its iron dredges and canvas nets, and all the information he could offer from his experience in fathoming deep waters and collecting marine animals. The Austrian Government thanked him for his kindness, and the volumes containing a history of the *Novara* expedition recognise his presentation of the apparatus mentioned above.

CHAPTER X.

A Mathematical Solution of Organic Forms—The Triangle and Crystal—Lectures on Man—His Addresses and Correspondence—The Respect shown him.

Towards the latter days of his life Goodsir bestowed the closest inspection upon the surface of organic forms: thus he traced the minute lines upon the human femur, their size, direction, and spaces of enclosure; then he mapped the palm of the hand, with all its linear markings, and compared these with the hand of the chimpanzee. It was not enough for him to note the general differences of these allied organs in man and his near neighbour, he must seek for the cutaneous and finer-shaded distinctions or disparities.

In 1864 he began to consider the type or plan upon which textures were arranged. His attention was first directed to the human muscular system of which he made dissections, models, and drawings. Having detached with great care the muscles from their attachments, he dissected out the fasciculi to show the manner in which they joined the tendon, and the direction of the fibres to form a fasciculus. He noted that fasciculi do not pass parallel to each other to join the tendon, but obliquely or diagonally, and ultimately to cross each other at angles; it was

the same with individual fibres comprising a fasciculus. The arrangement of the fibres of tendons was also in conformity with that observed to regulate the muscles, where the fasciculi and fibres do not proceed in one direction only, but are arranged in series of bundles whose form is triangular, and that they overlap each other at their apices.*

Goodsir had section after section of bone made with the view of examining the direction of the Haversian canals and the arrangement of the fibres of the solid osseous texture, also the direction of the tendinous and muscular fibres attached to the bony surface. By placing black bristles in the minute foramina visible upon the surface of the different sections, the oblique direction of these foramina, and the canals into which they open, either from below upwards, or *vice versâ*, was well shown, and the spaces between these bristles appeared triangular. People were disposed to smile at his anatomical minutiæ, yet those who looked narrowly at the same structures saw the same markings. Had he thought of it, he might have silenced opposition by citing the presence of a mere spicule of bone on the inner side of the humerus, leading Knox to prophesy a supra-condyloid foramen, as showing what a detective eye and responsive brain can do in elucidating Nature's types. He showed great facility in tracing lines and facets on osseous and other surfaces, in the same way as Sir David

* Dr. Hair, as Prosector to the class, assisted Professor Goodsir in these dissections. His own observations on the muscular fibres of the alligator (*Journal of Anatomy and Physiology*, vol. ii.) are interesting.

Brewster's keen vision directed to his special work enabled him first to see the ultra red portion of the spectrum, and to see it better than any other person ; in both instances it may be inferred that the optical sense could be extolled or heightened by force of will when the mind was intent on "light, more light."

A close scrutiny of the structure of organised forms, and a rigid comparison of the forms themselves, led Goodsir to the theory of a triangle as the mathematical figure upon which Nature had built up both the organic and inorganic worlds. The fundamental principle of form, he seemed to think, lay within the province of crystallography, and was to be discovered by a close study of the laws of that science. The first expression of his belief was in the museum in 1865, when, holding out his hand and bending the phalanges of his thumb towards the palm, thereby producing certain angles, he said to Mr. Stirling, "There is the triangle, the basis of organic forms."* He had his hand triangled, and this member he found to correspond with the angles taken from the head and shoulders, and other parts of his body. He considered that every organism could be enclosed in a figure of a precise and characteristic form, which he compared with a crystal, and that each part of an organism also

* It is essential to state that Goodsir left no MS. as a guidance to his ultimate views of the triangle, and that this chapter, as far as it attempts an elucidation of his theory, is based on the recollections of conversation with the professor ; and is mainly derived from his family and Mr. Stirling, his museum assistant, who for months laboured to carry out by various dissections and plans his master's triangle-hypothesis.

possessed a precise form, which viewed according to the laws of crystallography, was either the same form of crystal as that of the entire organism or a derivative from it. In explanation of his views as applied to the human body, he constructed a triangle, the two sides of which, meeting at a point above his head, passed obliquely downwards, touching the most projecting part of his shoulders, as far as his feet, whilst the base was a line drawn across at the level of the soles. He found that one side—viz. the right, was longer than the left, in his own case to the extent of two inches; and this preponderance of the right over the left side was invariably manifested by the different organic forms he examined. He then subdivided this triangle by transverse, vertical, and oblique lines, and found that they or their points of intersection corresponded to certain well-defined anatomical points or lines, as the epigastrium, umbilicus, ribs, knees, wrist, etc. By placing one of these triangles on a flat surface, and erecting from its sides and base three triangles of the same form, which met above, he enclosed a space in which the body he was examining could be contained, and the tetrahedron formed by the apposition of the edges of these four triangles he called the crystal. He argued what measures a man will measure a tree, and it was curious to see the comparison between his own figure triangled and a tree as a whole, including roots, their fibrils, the stems, and twigs. He looked in every field of organic life for illustration to his theory—to the vine and other trees, to fruits of home and foreign

growth, to the bills and feathers of birds, to the tortoise back and gorilla skull—possibly the

> "Eye of newt and toe of frog,
> Wool of bat and tongue of dog,"

as all were meet ingredients in his cauldron of inquisition.

Tubes like the aorta were demonstrable by segments of triangles. Even in the cancelli and foramina of bones, and the capillary network of vessels, he saw the angular element prevailing. As instances of his theory in the primitive structures, he cited the spindle-shaped cell—as consisting of two triangles united base to base; and he supposed that the blood-discs might break up into three angles like the lens of the eye, and possibly, if vision was sufficiently microscopic, the same tripartition might be seen in the organic granules or molecules.

Afraid of inaccuracy creeping into his calculations when startling results came forth, he was wont to exclaim—"Now, Mr. Stirling, let us have God's truth in the measurements. God's truth in everything! I live for that." As he believed that every cell had a parent cell or "a mother," so he argued there was an umbilicus or centre in everything in nature, and two sides, a right and a left. These sides he viewed as having opposite obliquities with reference to each other. Thus, in the limbs the different segments when flexed on each other presented alternate obliquities, and when the arms were folded over the chest so that the hands rested on opposite shoulders, an oblique

arrangement was recognised. The oblique overlapping of one structure over another he observed not only in the animal organism, but in the folia of a leaf-bud or the various parts of the flower.

The cell, viewed in its growth, its functions, and almost universality of purpose, gave weight to the supposition of man being simply a big conglomerate of cells, rising up, maturing, and decaying; with a better knowledge of the protozoa, Man became likened to a huge composite of monads striving their best for the common weal of the presidential *homo:* now Goodsir, who had admitted both these physiological hypotheses, went still further, and saw in the growth, the form and finished structure of Man—a tetrahedron. This doctrine—strange, nay passing strange—was based on a vast multitude of observations, culled with the characteristic assiduity of an enthusiast, and, more marvellous to say, sprang from the brain of a man who had all his life been solicitous for facts. It was occasionally thought that Goodsir's theories got in advance of his own facts, but at no time of his history had he shown such a tendency as now to imitate Goethe in his high flights, when he wrote to Herder that nature herself would envy him his penetrating into her mysteries.

In Goodsir's professional career, and mingling with the practical everyday aims of a great teacher, there crop out from time to time peculiarities of thought, highly speculative, now traceable to his German readings, but as frequently of native growth or Goodsirian genesis. If these psychological manifestations came with the

growing metamorphosis of age, they were also attendant upon fuller experience and a greater insight into his science. Thus his study of the *Nautilus*, and numerous shell-forms, inclined him to adopt the logarithmic spiral* as a teleological chart in nature's beautiful designs. As Newton, from the geometric forms, made out *the law of the force*, Goodsir conceived it probable that "the logarithmic spiral would be found to be the law at work in the increase of organic bodies." Then his consortings with D. R. Hay,† who rested his æsthetic lines on harmonic angles led to his more careful comparison of the skeleton with the human form; and this new inquiry elicited the belief that the measurements of limbs and regions are based on aliquot parts of an angle. The harmonic angles had their day, and vanished before the light of fresh observation — multiplied and re-multiplied to meet the requirements of a new ideality.

Apparently dissatisfied with the ancient mythological doctrines that placed a globe on the head of Atlas, and the beautiful analogies in the same direction advanced by Cicero (*De Natura Deorum*), and finding "the cellular theory" and others that he had helped to build up insufficient, he sought another foundation to the organic architecture, and discovered, as he be-

* Sir John Leslie was the first to indicate the organic aspect of the logarithmic spiral which he observed,—"exactly resembles the general form and the elegant septa of the *Nautilus*." (*Geometrical Analysis and Geometry of Curve Lines.* Edinburgh, 1821, p. 438.)

† *Vide* "*The Geometric Beauty of the Human Figure defined*" by D. R. Hay, F.R.S.E., published by Blackwood & Sons, Edinburgh, 1851.

lieved, the corner-stone of the temple in the triangle! The freemasonry emanating not improbably from the aborigines of the Nile, and that carried the triangle as an ark and symbol in *Io triumphe* procession through the "hundred-gated" Thebes to the grand temple of Karnak,—centuries before the suggestive basis of the "English inch" and "Quarters" were disembowelled by John Taylor and Piazzi Smyth from the pyramid and chambered caverns of Cheops of Gheezeh; the triangle—the high token of the Oineromathic Brotherhood, so ancient as to be lost in Eastern mythology, and now in everyday use as a feature of modern and public-marching fraternities—came to be invested by Goodsir with a higher significance than Eastern emblems clothed in the wildest of imagery—namely, the glory of type—the primitive form—the universal image of nature.

In seeking his grand ideal—a physiological law ruling the form and growth of organisms, as gravitation is held to prevail in the physical world—the last years of his life were as absorbing as his buoyant adolescence, if not the most interesting of all; for as his body became increasingly weak his spirit soared higher and higher to the pinnacle of speculation. The happy psychological condition prevailing with the phthisical patient seems to have been meted out to Goodsir; with hopes of a longer life, a kind of optimism took possession of his faculties. His bodily powers were daily deteriorating; his hours of sleep were short and unrefreshing, and the enjoyment of society had vanished for ever; but there

was one earthly solace left—sweet and passing sweet to him—discovery. With this phantom of the mind alluring him on, he fought against the fates, disregardful of the daily severance of life by the black-veiled Atropos. He seemed to possess a strength of soul that enabled him to stave off pathological changes—the grand help to this fortitude being the "Triangle" theory of formation and law that he hoped to complete as the greatest of his earthly work.

Readers of this sketch will be apt to treat Goodsir's triangle as Schiller behaved after listening to Goethe's theory of the metamorphosis of plants, by a shake of the head, and saying—"All this is mere idea, and not founded on observation;" to which Goethe replied, as probably Goodsir would have done in defence of *his* universal image, that "it was agreeable to have ideas at his command, and particularly to see the reality of them with his own eyes." The Goethian doctrine, once so much laughed at, has long been accepted by the world. Time will show if the same fate will attend Goodsir's idea as to Man—a psychical being and of "form divine" being but a crystal in his structural entity and arrangement.

The title he adopted for his lectures on man—"On the Dignity of the Human Body"—is highly characteristic of Goodsir. It augurs respect for the *physique* of humanity,—it honours the form of man as a type of excellence,—and seems to breathe of reverential regard for the precedence and lordliness enshrined therein. At the threshold of his argument

he wishes distinctly to set forth that Humanity stands not only in degree but in kind, above Animality,—that man is a being invested with a masterly privilege over the brute,—and that the bodily form, as the representative of a psychical governance, wears a true dignity of character. Throughout this series of lectures on man, Goodsir has given an anatomical and philosophical explanation of a deep meaning of Spencer the poet, couched in the following lines in "An Hymné in Honour of Beautie"—

> "For of the soule the bodie form doth take;
> For soule is forme, and doth the bodie make."

He argued for the absolute completeness of the structural characteristics of man. The animal body might be complete as far as the purpose of its creation, but incomplete as regards the type of structure on which it is formed—in other words, teleologically complete, yet morphologically incomplete; whereas the human body he considered complete in both respects. In his exaltations of man, he was not forgetful of the existence in the animal of a principle allied to human consciousness.

In his lecture on "The Essence of Humanity," he held that tradition, history, and revelation combined in assigning a locality in the North Temperate Region for the original area of man. He looked upon the arrangements by which "the erect position in man" is maintained as involving the conception of absolutely complete structure and as highly important

relations to the rational consciousness in humanity. In treating of the "Upper Limb in Man," he contrasts it with the same structures in the *Quadrumana,* and after pointing out the essential differences, says, "The principle on which the completeness of the upper limb is based consists in its purposes as an instrument for acting on matter, in terms of his human faculty of thinking in space." He believed that speech was conferred upon man by an immediate or Divine process or act, that man has no control over language—he is merely an unconscious agent in its changes and progress.

In his lecture on the skull and brain, he entertained the firm conviction that "the human brain exhibits in its geometrical proportions and mass a great superiority over the brain of any other animal—a superiority similar to that presented by the human bones, joints, muscles, and organs of sense," and that "its structural and functional completeness distinguish it from every other form of brain." Goodsir held the doctrine that symmetry of brain has more to do with the higher faculties than bulk or form. Bichat entertained a similar opinion, as he looked to want of symmetry in the two sides of the cerebrum as a cause of insanity. Strange to say, the brain of the man of genius, Bichat himself, was found to be remarkably non-symmetrical. In showing "the position of man in the scale of being," he holds that the revealed record should be taken into account in the general discussion of the subject; and that man in his consti-

tution consists of three elements — a corporeal, a psychical, and a spiritual. In treating of "progressive man" in the last lecture of the series, and of the influence of Christianity on man, he said—"I would only impress upon you, as students of science, that science, properly so called, had its origin within the Christian era; that its progress is one of the results of Christianity; and, moreover, that one of the greatest dangers to which the Christian system is at present exposed is the erroneous tendency to elevate science above the other forms of human belief."

However man was to be viewed relatively, Goodsir aimed, in the first place, at an accurate definition of his physical lines and form—a great desideratum in anthropology; and his anatomy, though very briefly set forth, is admirably done. He had a greater object in view, however, and that was the declaration of his psychological views of man, in the hope of checking the growing Darwinianism in England, and counteracting the impression made upon the members of the Edinburgh Philosophical Institution by Professor Huxley's lectures on "The Relation of Man to the Lower Animals." In his anatomical and medical inquiries he had always stood out for man's superiority in the scale of being, his high attributes and spiritual relations. As a professor, he felt bound to show his colours; nay, he held it to be an imperative duty to defend the citadel of orthodoxy against what he deemed an unqualified and hasty expression of thought. Speaking with the authority of an anatomist, and adducing

reasons for maintaining the existence of the *psyche* or psychic principle, and the *pneuma* or spiritual element in man, he rendered important aid to the cause he espoused. His anatomical and physiological opinions, as well as his psychological reasonings, will naturally come to be examined from different points of view; for, as Pope says,

> " 'Tis with our judgments as our watches, none
> Go just alike, but each believes his own."

and since science has broken loose from theological dogmas and state churches, it has shown a tendency to a bold reaction of feeling against all records but its own.

Being elevated to the chair of every society, excepting the "Royal," of which he was a member, he was called upon to deliver many introductory addresses, and not unfrequently to give his views on special subjects of inquiry, of current interest to the society. His addresses to the "Medico-Chirurgical Society," and the "Royal Medical," printed in this volume, are furnished as examples of his style and train of thought in both directions. His appearance at the "Royal Medical Society" was hailed with pleasure by the oldest representatives, as well as the students belonging to the society; and his treatment of his subject—"Life and Organisation"—was viewed as no less felicitous than philosophical.

In his capacity as "Promoter," he was twice called upon to address the medical graduates on their as-

suming the honours of *Doctor Medicinæ.* These addresses were carefully written out, as he held it right to be methodical and accurate, and that parting words of advice should be appropriately tendered to those who, as *alumni*, had been under the sheltering wing of their *alma mater* for years, and who, as graduates, might be expected, as they should be encouraged, to uphold the dignity and interest of their profession.

After the first year of his professorship, he moved from Lothian Street to a large house in George Square, which he fitted up in good style; there he received many of his old friends and numerous visitors from the Continent; and there no doubt he hoped to find in surgical and consultation practice a new field for the display of his abilities. Disappointed in his hospital aims, and otherwise harassed, he took up his residence in Charlotte Street in the New Town. Here his habits underwent a great change. To avoid visitors he went to bed at 8.30 P.M., and rose before 5 A.M.; in this way he got five hours work done before Edinburgh had breakfasted. He lived in rigid simplicity and did nearly everything for himself; the sofa of the day became his bed of the night, so that he slept amidst his papers and special preparations, and could dress or turn to work at any time without the fear of intruding domestics. For some years he sought the country by the shores of the Firth of Forth, and lived at the Trinity Baths, three miles from the University. He moved from the baths to Edinburgh again for eighteen months, and then finally settled at South Cottage,

Wardie, where Edward Forbes died. South Cottage, though only 200 yards from the sea, was quite hidden by other dwellings, and as a low-roofed, inconvenient and dingy residence, was quite unfit for an invalid like Goodsir. In 1862—and the fact is mentioned to show that so late as that year, he was still aiming at a life of labour, around which greater domestic comfort should be associated — he bought a feu, or bit of ground, at Wardie, to build a house upon, and from which he could always command the sea. The house was to be based on new architectural principles, and the designs given by Goodsir interested Mr. Cousin, the city architect of Edinburgh, exceedingly; indeed, the designs were nearly completed when his growing infirmities came in the way and superseded all earthly constructions, but the fame and honours attached to science.

Professor Goodsir was in the habit of receiving letters from every man of note in anatomy and the natural sciences in Europe. He was viewed in an amiable light by all of them, and not a few showed him cordial friendship, if not the most confidential intimacy. Considering his reluctance to the epistolary form of writing—for he was a much worse example than Talleyrand in the way of putting off his replies from day to day and month to month—his correspondence is strikingly curious as coming from all sorts and conditions of men—*e. g.* Canongate artisans, country surgeons, English and Irish naturalists, and Scotch noblemen. The majority wrote him on ana-

tomical and scientific matters; but he was expected to be *au fait* on education, college reforms, fisheries, veterinary medicine, and agriculture, *cum omnibus rebus et quibusdam aliis.*

Great confidence was reposed in Goodsir's observations and accuracy, in his museum work, his published writings, and anatomical opinions, theoretical and pathological. Abroad, and in the best schools of Europe, the feeling towards him and the Edinburgh School of Anatomy almost approached the expression of Haller *quoad* the Monros; and *Goodsir ibi eminet* would have been no undue representation of the respect entertained for him for many years. As early as 1845, the publication of his *Anatomical and Pathological Observations* gave him a good position both at home and abroad. This position was enhanced in February 1850, when he issued the first part of his *Annals of Anatomy and Physiology,* bearing the logarithmic spiral on its cover, and consisting of six sheets of original matter, illustrated in the best style of art. No British anatomist felt satisfied with less than a personal introduction to the Edinburgh professor, as an able representative of the science and its new teachings; and one distinguished German, it is said, thought it a sufficient recompense for his travelling so far as Edinburgh that he had seen John Goodsir. He had a mutual good feeling towards his contemporaries in every walk of medicine, and especially for those who like himself were showing a love of science, and no less noble endeavour to extend the lines of dis-

covery and to widen the basis of philosophy. He spoke pleasantly of his English friends, and highly of Professor Owen, whose labours in teleological anatomy he greatly valued, and whose papers on the *Aye Aye* (Chiromys) of Madagascar he used to cite as a model of what a scientific paper should be. When the British Association met in Edinburgh in 1850, Professor Goodsir was elected president of the physiological and zoological department, and discharged his duty with his wonted ability and success.

CHAPTER XI.

Last Illness—Hopes of the Future—Death—Opinions of the Press regarding Goodsir—Resumé of his Character.

Each year after 1863 saw the professor feebler in the use of his limbs, and less able to cope with the higher studies of his science. His irritability of feeling increased with his bodily suffering, and he seemed best when left alone in the museum. No one, either at home or abroad, threw much light upon his pathological condition; nor does he appear to have tried any remedial measures of moment after his return from Germany. He eschewed society, and became more and more of a hermit at Wardie. At home he was constantly reading, or being read to by his sister, who also lightened some of his evenings by playing on the organ or piano. Though disabled so much in body and shattered in nerves, he did not cease to labour. Work was before him, and this filled his mind with hopes of life and the further enjoyment of his intellect. He fought against disease as few men have fought, and seemed to live, as if by the sheer force of his own will he could contend against the enervating and devitalising influences sapping his frame from day to day and year to year. As he grew

feebler, the loss of co-ordinating power over the muscles of his lower limbs increased, as also the difficulty experienced in walking, except when he looked intently at his feet. The hyper-sensitive condition of the skin, especially in his lower limbs, was so great, that at times he could scarcely bear the contact of his clothes. These deteriorating changes were accompanied with loss of nutritive functions and great emaciation.

Contrary to the advice of his friends, the professor commenced his usual winter course of lectures in November 1866. Before the month expired he had a fit, and fell in the presence of his class, and had to be conveyed home. He resumed his work in a few days, and, despite his sufferings and the daily entreaties of those who saw him dying on his feet, he continued to lecture till nearly Christmas. He had become little more than a shadow of his former self,—his physiognomy betrayed a wearying painful illness and solicitude, as much as the fissured lines of his face showed premature old age and rapid decadence. Every act of his life was but a feeble effort against the shackles that fettered his *physique* and limited his mental operations. It was a terrible struggle—the struggle of a strong will and earnest hopeful spirit to accomplish public duty. During the few weeks that intervened between the forced abandonment of his class and his death he was mainly confined to bed. "Born and reared in a religious atmosphere," as his sister, who tenderly watched him in his last pilgrim-

age, writes, "his public teachings proved the worth of his religious principles; notwithstanding my previous knowledge of him, it needed the involuntary utterances of a death-bed to show me all the simplicity of mind and godly sincerity of heart with which those principles had been fostered. As he had been an interpreter of God's works, he had been also a diligent student of His revealed Word, and a truly humble Christian."

When the pleasure of meeting his class was denied him, he often spoke of his pupils; and as he had conscientiously laboured to advance their studies, persuaded himself that some of them would live to interpret his oral teachings and extend the knowledge of his philosophical views to another generation. The anticipation that his finished labours would stand the test of time, and that his outlined work would be filled up and coloured by those he had taught and indoctrinated so well, were like pleasant breathings, if not anæsthetic repose, to the Goodsir couch, and could not fail to lend a halo to the hopes of a reputation beyond the grave.

As evidences of his philosophic, religious, and speculative leanings to the very last, he had placed on a table beside his bed a large folio copy of Sir Isaac Newton's works, in five volumes, the Bible, and a work on Crystallography, with a tray of models to illustrate the intended publication of his views of organic form on a triangular basis—that *magnum opus* of his latter-day ideal life.

He was attended during his last illness by his old

friend, Mr. Spence, professor of surgery. After much suffering, and within a few days of completing his 53d year, he died very peaceably on the 6th March 1867, in the presence of his devoted brother and sister, and in the same cottage (South Cottage, Wardie) that witnessed the last hours of his friend Edward Forbes (Nov. 1854). The youthful companions—John Goodsir and Edward Forbes—who had sat on the same benches as students, and had fraternised so well in natural history research, and struggled up the arduous steep of science to professional eminence and European fame, came to breathe their last under the same roof. And as if the ties of life and love were to find a fitting response in death, the remains of John Goodsir are interred next to the grave of Edward Forbes, in the Dean Cemetery of Edinburgh.

John Goodsir's funeral was attended by professors and medical teachers, the fellows of the royal colleges, and many mourning friends. Two hundred of his pupils joined the procession, and manifested their deeply-felt sorrow at the graveside of one whom they loved so much. A granite obelisk marks the grave, and upon it are inscribed the simple words—"John Goodsir, Anatomist. Born March 20, 1814. Died March 6, 1867." The Rev. J. T. Goodsir has had the spiral curved line engraved on one side of the obelisk, to exemplify the feeling pervading the professor's mind on the subject of organic growth—the spiral being symbolic of *the law of the vital force*, set forth in p. 180 of this memoir, and more developed in Goodsir's

human and comparative, than John Goodsir. * * The only regret will be that he has left so few records of his discoveries and conclusions; that in the keenness of his pursuit after scientific truth, he left himself so little time to gather up and embody in a lasting form his numerous incidental felicities of investigation and doctrine. But enough, and more than enough, will always remain to prove the brightness of his intelligence, the justness of his reasoning, and the philosophic comprehensiveness of his generalisations. * * No subject, however remotely connected with his favourite one, but was perfectly known to him. When in 1854 he suddenly undertook the task of lecturing on natural history for his deceased friend Edward Forbes, he was found a master, at every point, in the science which was only accessory to his own.

"It is indeed impossible to estimate aright the loss which scientific knowledge and academic education sustain through such a death as his. Let us hope that the generous contagion of his teaching and the lustre of his example will arouse in some worthy disciple the masculine enthusiasm, the noble candour, and the chivalrous self-devotion which are buried in the too early grave of John Goodsir."

Professor Balfour, in the obituary notice of his departed friend furnished to the Botanical Society, said: "By his death science has been deprived of an original thinker, a most zealous and successful worker, and his pupils have lost a warm and devoted friend and teacher."

The Scotsman and *Evening Courant* in Edinburgh, and other Scottish newspapers, and notably those of

Fife, gave brief notices of Goodsir's life, work, and character.

The institution of fellowships in the University of Edinburgh, so long advocated by Professor Goodsir, seems to have been well understood by his surviving friends, as on the first occasion of their meeting to do justice to his memory, they came to the decision of founding a fellowship in his honour. The writer hopes that this idea, so consonant with his departed friend's wishes, will be carried out in a manner worthy of the University and the man to be memorialised.

A pure thought, a simple mindedness, and unobtrusive religious feeling guided John Goodsir in both his private and public relations. Nothing mean nor sordid, nothing small nor covetous ruled him who cared but little for the allurements of the hour or the glitter of popularity. Cicero's words *pro M. Cælio* were fairly applicable to Goodsir—"*Quem non quies, non remissio, non æqualium studia, non ludi, non convivia delectarent; nihil in vita expetendum putaret, nisi quod esset cum laude et cum dignitate conjunctum.*"

As a professor and cultivator of science, Goodsir kept Haller, John Hunter, and the Meckels in view as types of men whose discoveries and teaching he should hold up as examples to his own high calling—men who tried to grasp the science in all its totality. It was on this ground that he admired Johannes Müller Retzius, Hyrtl, Vrolik, and others who followed the footsteps of the great anatomists and physiologists of the last century. Of the school of the past Goodsir himself resembled Monro *primus* in preparing and

lectures—vol. ii., art. viii. A similar obelisk, without any device, stands side by side with Goodsir's, and bears—"Edward Forbes, Naturalist, born February 12, 1815; died November 18, 1854."

The autopsy and the microscopic examination of the spinal cord were made by his assistants Dr. Chiene and Mr. Stirling.

The brain weighed $57\frac{1}{2}$ ounces avoirdupois, and was rich in convolutions; it was anæmic, but otherwise apparently healthy. The cord was removed below the third cervical vertebra, and weighed, together with the membranes and nerve roots, 3 ounces. The membranes were thickened and opaque, more especially on the posterior surface, the opacity of the arachnoid prevented the observer from seeing the condition of the cord until that membrane was removed. There was no appearance of recent inflammatory formation. The posterior roots and their ganglia were congested. The cord was greatly atrophied, and the cervical and lumbar enlargements were no longer recognisable: a common drawing pencil flattened on two of its surfaces may give an idea of its circumference. After hardening in chromic acid, it was found impossible to make perfect sections, either transversely or longitudinally, as the columnar part of the cord, more especially posteriorly, broke away from the grey matter. These sections were not so distinctly coloured with carmine as in a healthy cord. The grey matter examined with a power of 300 diameters presented large and distinct multipolar nerve cells in the anterior horn of the lumbar

part, which cells, indeed, seemed bigger than in a healthy cord in the same locality. In the cervical region they were smaller and fewer in number than in the lumbar part, and with yellowish contents, which did not take the carmine tint. Both in the lumbar and cervical regions the columns were greatly atrophied, and with an almost complete disappearance of the axial cylinders of the nerve-fibres; sections through the columns exhibited an irregularly reticulated appearance, with intermixed granular matter: *corpora amylacea* were scattered in considerable numbers throughout the substance of the cord.

The Senatus Academicus of the University of Edinburgh, at their meeting of 9th March, adopted the following minute:—"The Senatus deeply regret the loss which they have sustained by the death of Professor Goodsir, who for twenty years had ably discharged the duties of professor of anatomy. They feel that the University has been deprived of a most distinguished man of science, who, by his knowledge of human and comparative anatomy, had acquired for himself a European reputation, and who, by his prelections and writings, had done much to maintain the reputation of the University."

A writer in the *Pall Mall Gazette*, who seems to have comprehended Goodsir's character very fully, says—"Since the days of John Hunter no greater master of anatomical science, no keener investigator of phenomena, no more comprehensive grasper of generalisations, no clearer or more effective expositor, ever dedicated himself to the great subject of anatomy,

moulder's hand; but which, if fashioned, might have constituted walls of building to the Goodsir fabric, not only displaying his character as a worker, but contributing its part to the general architecture of science that he laboured so earnestly to extend and beautify.

If disposed to the golden silence that marks the man of deep thought, his conversation, when elicited, was characteristic of sagacious observation and knowledge. To his pupils it was particularly instructive; it reflected his large acquaintance with his own subject, and extensive readings of the collateral sciences; there was no waste of words, no high composite; occasionally the argument might assume an elaborate or parenthetical form, but more frequently his ideas were conveyed in a pointed and precise way—Scottish, if not dogmatic, and essentially Goodsirian.

His anatomical lectures constituted a great fact in his history both as a man and a teacher. No one in Britain seems to have taken so wide a field for survey, or marshalled so many facts for anatomical tabulation and synthesis. Goodsir's place on the historical tablet should be measured not only by his published writings, but by his museum creation and work, and his professional teachings of thousands of men, and through them the germinating ideas he has scattered broadcast over the world of medicine. He not only taught in his own way, but inspired others by his teachings. He not only gave the anatomical data or the facts, but illuminated these facts by various lights and interpretations, as if revealing fresh facets on the crystal, and therefrom educing a fresh polarisation.

There was no moderation in Goodsir's working, and not even the relaxation which change of pursuit favours to a certain extent. It was daily, dogged, downright labour; he used his body as if it were a machine, and his brain as if nervous matter could be supplied as readily as English coal to a furnace. He exhibited in his own person what is aptly designated the wear and tear of life, with every nerve in full tension as if for concert pitch. Scores of friends advised him, personally and by letter, to spare his energies; but Goodsir, prepared to "shun delights and live laborious days," took no heed of the morrow of life; now and onwards and for ever reflected his belief. He seemed buoyed up with a passionate fervour that would brook no delay and no temporising with its aim and purpose. Incessant work, continued for a series of years, led to the usual result—impaired health, functional disturbance, and pathological change. To escape from the dissecting-rooms to the quiet of country life, and "to babble of green fields" is the great desideratum of every anatomist, and no men enjoy their holidays more thoroughly; but Goodsir scarcely ever realised what relaxation was. When he spent a summer abroad, it was not by the banks of Lago Maggiore, or sipping the waters of Brunnen, but in the museums of Berlin and Vienna. On his return from a Continental trip, when asked by a friend how he enjoyed his autumnal holidays, Goodsir, with great truth and simple-mindedness, replied—"Oh! very much indeed. I spent six hours a-day in the museums with Müller, Hyrtl, or Kölliker." Change and travel soon palled on the

collecting anatomical specimens, in the study of comparative anatomy, and in the application of his science to practical medicine and surgery.

In addressing intimate friends he used to remark, towards the close of his career, that he had not done justice to himself—a spontaneous comment on the past of very significant meaning. As a deep-rooted conviction, such a feeling could not fail to have a saddening effect upon a man sensitive to a degree regarding his achievements in science, as it implied either neglected opportunities in the exercise of his powers, or dissatisfaction with his scientific status, or a latent fear as to the permanency of his work beyond his own epoch. Though this latter feeling did not exist in Goodsir's mind, probably however in seeking present fame and historic repute, as all true and faithful men do, Goodsir committed the error of attempting too much—more indeed than could well be accomplished. He aimed to win four great prizes in life, any one of which would have been a "blue ribband" to most men, even of those who bid fair for high place in the competition. His hopes were fixed on being—1*st*, a great teacher of anatomy; 2*d*, a surgeon of distinction; 3*d*, the founder of a Goodsirian Museum; and 4*th*, to rank as a man of science with the greatest of his epoch. Some of these cherished aims were incompatible with each other. The second—surgical practice—was necessarily a failure or the first—anatomical teaching—could not have been so truly and eminently a success. The third, or the museum of high and undisputed excellence, is a monument to

his industry, his art, and his research. Of his position in the natural sciences a varied sentiment may prevail, owing to the difficulty of assigning to a many-sided observer like Goodsir one side of real greatness that is incomparably manifest and larger than all others. His observations on the teeth, his many original contributions to cellular physiology and pathology, his application of geometry to the study of anatomy, and his morphological disquisitions, stand as undoubted claims to honourable distinction in anatomical, physiological, and pathological science.

He had accumulated note-books, and an extraordinary amount of manuscript on anatomy and various branches of knowledge; but, with the exception of the papers noticed in these volumes, nearly all his writings were imperfect and incomplete. There were heads of lectures, sketches of greater works laid down in a series of propositions, and plans for the publication of monographs on subjects somewhat apart from anatomy, but which he thought capable of Goodsirian elucidation. These *dicta collectanea* were like *passim* records of ideas that floated him bravely on the sea of time—to-day of *couleur de rose* prospectus; to-morrow cast aside for more captivating allurements to the Goodsir æsthetics. Many of the changes, however, in his scientific and literary programme arose from circumstances beyond his own control: the pressure of public duty, not unfrequently of public exactions, ill health, and other hindrances. It was painful to turn over such a host of fragments, and to see the wasted labour of years lying like debris on the earth; or as clay without the

DIVISION I.

LECTURES AND ADDRESSES.

Goodsir fancy; there was nothing so tempting to him as the investigation of organisms; nothing so captivating as the paths of discovery in natural history.

Labor ipse voluptas might have been added to the Goodsirian motto of *Fidelitate et virtute,* for assuredly he acted in accordance with both sayings, till at length labour became a monomania that the most intimate friends could not change. A gentleman wrote him in 1848—"Suffer a word of caution from an old friend. It is better to live for the advancement of science, than risk adding another name to the list of its martyrs." A pupil in 1850, after expressing veneration for Goodsir's science and philosophy, implored him not to overtask and strain the natural limits of his bodily strength; and these letters were but the echoes of many others from kind friends. Had he husbanded his resources, mental and bodily, after 1848, and sought the domesticity of married life and the amenities of the social world, the rural cottage in the summer months, with botany and horticulture as diversions, he might have been spared for years, and benefited science more largely than he had done. As it was, he lived only for science, and unquestionably died in its service.

H. L.

DIVISION I.

I.—ON THE DIGNITY OF THE HUMAN BODY.*

LECTURE I.

THE NATURE OF ANIMALITY.

1. The object of this course of lectures is to illustrate the absolute completeness of human structure, when compared with the merely relative completeness of animal structure. The term animal is used to indicate all the forms below man.

2. The conditions of life in any given form of animal supply the grounds on which the relative completeness of its structure may be inferred—these conditions are, climate, food, geographical area, etc.—and, in like manner, the conditions of human existence indicate that absolute completeness which constitutes the structural characteristic of man.

3. It is therefore essential, for the satisfactory study of the relative and absolute structural completeness of the animal

* The ten following lectnres "On the Dignity of the Hnman Body, considered in a comparison of its Strnctural Relations with those of the higher Vertebrata," were delivered to the class of Anatomy during the summer session 1862. The mannscript from which we have printed was arranged in the form of propositions, which were read to the class, and then illnstrated by additional observations, and when practicable by a reference to specimens and diagrams. We have, from notes taken at the time by one of the anditors, expanded many of these propositions by adding to them the additional observations made, and by reprodncing some of the most important diagrams. —Eds.

and man respectively, that we should possess clear conceptions of the relative conditions of animal and human life.

4. I shall devote this lecture, therefore, to the consideration of the conditions of existence of the animal, and to the question as to the nature of animality.

5. My second lecture will involve the consideration of the condition of human existence; and of the question as to the essence of humanity. We shall then be prepared for the consideration of the special subject of the course.

6. The conditions of existence of an animal are indicated in the constitution of its specific economy. A species can only exist over a geographical area having certain conditions of geological structure, of climate, and of animal and vegetable forms. The characters of the living economy of an animal species may, indeed, become more or less modified, or the number of its individuals may diminish, in accordance with modifications in the cosmical conditions of its area of distribution. But there is a limit to such permitted modifications of specific character; and if the cosmical conditions of its existence pass these limits, the species disappears.

7. In a subsequent part of the course, I shall state the grounds on which we are compelled to assume that each species of animal was directly created for its proper area. In the meantime, I lay before you two important principles, which I may state thus;—

1*st.* The conscious element of an animal is virtually the animal itself; for it is that, failing which the body of the animal would have had no existence. It is that element in the animal constitution which is immutable. For although the constituent parts of the corporeal structure of the horse, dog, or pigeon, along with the instincts co-ordinate with those parts, may, by certain natural or artificial rearrangements of the specific conditions of the animal's existence, undergo very great modifications, nevertheless, the fundamental attributes of its conscious

element—which collectively constitute a horse, dog, or pigeon —remain unaltered, whether the animal has assumed a degraded or an elevated type of its specific form.

2*d*. An animal is adapted to its geographical area by the endowments of its conscious principle, of which element its corporeal structure is the mere instrument.

8. Every animal reacts on the area which it inhabits; that reaction being, in fact, the final purpose for which the animal was created. The animal, therefore, while indirectly advancing, through its instinctive consciousness, the end proposed in the creation of its species, by providing for the sustenance of its own body, and the reproduction of its own kind, is also engaged directly but instinctively in the furtherance of that progressive modification of its own portion of terrestrial surface necessary for the present existence, and for the future and higher purposes for which that area is destined. Thus, it is indirectly engaged in furthering its Creator's plan.

9. If the principle which I have stated be correct—that the structure of an animal is merely the instrument of its instinctive consciousness—then the conclusions to which we must come are most important. For, if we be correct, then we must look for the specific character of an animal not merely in its corporeal structure, but fundamentally in its instinctive consciousness, and in the manifestations of that conscious element. We must also look for the explanation of the dependence of specific animal forms on their appropriate geographical areas, not in the mere adaptation of their corporeal structure, but more immediately in their specific instinctive consciousness. When a species ceases to exist, we must consider its disappearance as the result, not of a mere struggle for existence with other animal forms or with cosmical conditions, nor of insufficient adaptivity to such extent of altered conditions of life as its specific endowments admit, but as the more or less direct result of the law impressed upon its instinctive

consciousness, in virtue of which it must cease to exist, when no longer supplied with the conditions on which its activity and faculties may be exercised through the instrumentality of its corporeal vehicle.

10. As the instinctive consciousness, the corporeal structure, and the geographical area of an animal species, are three co-ordinate elements in its specific constitution, it is evident that any one of these elements can only be efficiently investigated when the other two elements are fully represented in the question.

11. By this comprehensive method, applied to the investigation of the structure of an animal, we are enabled to see how the *body* of an animal, although complete or fully fitted to serve as the instrument of the animal's instinctive consciousness towards the fulfilment of the purpose of its creation, may, nevertheless, be incomplete as regards the type of animal structure on which it is formed. We express this technically when we say, that the structure of an animal is teleologically complete; but morphologically incomplete. It is the object of this course of lectures to indicate the grounds on which the human body is to be viewed, not only as teleologically, but also as morphologically complete. In this twofold corporeal completeness we shall, I believe, find a structural characteristic, which, along with his possession of a higher and distinct form of conscious principle, leaves no place for man in any conceivable arrangement of the animal kingdom.

12. The further elucidation of the relative position of man to the animal kingdom, involves a closer examination of the nature of animality.

13. If we are correct in assuming that the corporeal structure of an animal is merely the instrument of its instinctive consciousness, then it must be to this instinctive consciousness that we must look for the essential characters of animality.

14. As the facts of human psychology are attained by a process of self-examination, it is evident that we can only investigate comparative psychology by an indirect method. Nevertheless, as we can compare the combined instinctive and rational elements of our own human economy, so we may with confidence conduct our indirect comparative psychological investigations under the control of our own experience.

15. There can be no question as to the existence in the animal of a principle allied to our own human consciousness. This is admitted by common consent. Every unbiassed observer who has studied the actions of the various forms of animals, from the protozoon upwards, must feel impressed by the manifestations presented of an ascending series of forms of consciousness ; a series co-ordinate with the series of structural forms in which their presence is manifested.

16. These manifestations evince in various degrees of distinctness, as we ascend in the series, three fundamental conditions or states of consciousness.

1*st.* As the consciousness is manifested in sensation and perception.

2*d.* As it is manifested in the appetites, emotions, passions, social impulses, and special habits ; and

3*d.* As it manifests itself in the determining power or will.

17. In attempting to assign a precise value or meaning to the terms sensation, perception, appetite, emotion, passion, will, when applied to forms of consciousness in an animal, we can only proceed by the indirect method.

18. The sense of vision, as manifested in the animal, affords a satisfactory illustration of this indirect method of inquiry. The organ of vision is met with very low in the animal series.

19. However varied the structure of the eye may be, it is always constructed on optical principles. The refractive media of the eye are so arranged and constructed as to trans-

mit the rays of objective light, which impinge upon them, in given directions to the retina. In the retina, the objective light, by the instrumentality of certain structural arrangements—the rods and cones—induces the usual nerve action in the fibres of the optic nerve. This nerve action, common to all nerve fibres, is a polaric physical action ; proceeding by the optic nerve from the retina to the nervous centre of vision in the brain. At that nervous centre the consciousness of the animal interprets the objective or physical nerve action as subjective light.

20. This subjective light, or light usually so termed, is a mere condition or form of consciousness ; it is the psychical co-ordinate of the physical luminiferous oscillations, which are merely its mediate inducing cause.

21. By these successive actions, physical and psychical, co-ordinated by the optical construction of the eye-ball, and of the light-perceiving portion of the brain, the animal perceives at once the object presented to its eye. It sees it *directly*. The animal can determine without effort not only the distance of the object, but also without hesitation, the precise positional relations of the object to surrounding objects, and to itself.

22. This faculty of using the organs of vision, and the other organs of special sense, as *immediate* instruments, is peculiar to the animal. Man cannot do so. To him the organs of sense are *mediate* instruments. He must learn how to make use of them. He must learn how to interpret their revelations under the guidance of his rational consciousness. The animal requires no such self-education.

23. The illustration which I have given of the process of vision in the animal, affords fundamental evidence of the peculiar character of its conscious principle. Now, if we assume, as we may safely do, that all the other conditions of its consciousness are fundamentally determined in the con-

stitution of its conscious principle, we have a clue to the solution of the question as to the nature of that conscious principle, as distinguished from the rational consciousness of man. We are led to see that all the conditions of the consciousness of the animal are, in given circumstances, predetermined for it. The consciousness of the animal is not called upon to pass through a series of phases, or to go through processes under the guidance of a higher reason as in man. The mental processes in the animal are simple and direct; and, moreover, it cannot transgress their laws.

24. Up to this point we have traced the peculiar character of the consciousness of the animal, in relation to its sensations and perceptions. If we assume, as we may again safely do, that the animal conscious principle has its processes in relation to its emotions, appetites, passions, social impulses, and special habits, strictly predetermined in its own constitution; then it follows, that all its actions in relation to these various conditions must be directly and precisely fulfilled. The animal consciousness, then, cannot have presented to it any question in reference to any of its so-called emotions, appetites, and passions. It allays each and all of them according to their urgency, and therein instinctively acts up to the design of its Creator. The mental processes of the animal are simple and direct. It cannot transgress laws unless man leads it wrong.

25. Again, that phase of the consciousness of an animal in which it appears to determine an act, or to exercise *a will*, is undoubtedly a condition strictly predetermined for it, in so far that the act can only be resolved upon and accomplished under certain conditions. An animal has *no will*, in the proper sense of the term. In like manner, it cannot be conceived to possess a choice between right and wrong, action or inaction.

26. All the conditions of the conscious principle of an

animal, whether they be induced by objects from without, or originate in the inner or proper processes of the conscious principle itself, or exhibit themselves under the aspect of a will, would thus appear to be as fully predetermined in the economy of the animal's specific conscious principle, as are the specific structures provided for its corporeal economy.

27. We apply the term instinct to the collective manifestations of the peculiar co-ordinated, and consequently predetermined conscious principle of the animal. It is evident that the term conscious, when applied to the mental principle of an animal, must be understood in a modified form. Man is conscious not only of feeling, thinking, and acting, but he is also conscious that every feeling is followed by an act of thought; and that thought itself is a process which necessarily precedes an act of will. He is, moreover, conscious that he may act or not as he pleases. He is conscious of being able to resist the impulses of his emotions, appetites, passions, and of regulating his entire economy by his conscious principle. I allude to these characteristics of the human consciousness at present, for the purpose of producing a clearer impression on your minds of the nature of animality, when contrasted with the essential features of humanity.

LECTURE II.

THE ESSENCE OF HUMANITY.

1. We now proceed, guided by the principles involved in my last lecture, to examine the conditions of human life, and to inquire into the question as to the essence of humanity, so as to attain a basis for the discussion of the subject of this course.

2. As in the animal, so in man; his entire economy must be co-ordinate with his area—or, as we must term it in his case, sphere of action.

3. Man has not been created for any area of a given geological, climatal, or phyto-zoological character. He inhabits the entire globe.

4. From the principles on which we proceed, it is evident that the extension of man over the globe has been provided for in the superiority of his psychical, and consequently of his corporeal, endowments.

5. It is also evident, that as the animal is so constituted, psychically and corporeally, as to be capable, not only of sustaining its own life and of propagating its species, but also of acting efficiently, and without failure, in promoting the development of the area which it inhabits; man must in like manner be so endowed, psychically and corporeally, as to enable him not only to sustain himself and propagate his kind in all parts of the globe, but also to act towards the development and improvement of the entire surface of the earth, in a manner and to an extent, co-ordinate with his endowments.

6. Tradition, History, and Revelation, the three sources

from which the anthropologist derives his most essential facts, combine in assigning a locality in the North Temperate Zone as the original area of man. We must assume, therefore, that a temperate zone affords more immediately the material conditions of human life and welfare. Nevertheless, man has gradually extended the area of his habitation, or temporary occupation, into the Torrid and Arctic Zones; and as no arguments can be drawn from ethnological science in opposition to the assumption that man—in that gradual advance in power over material nature which is one element of civilisation, along with that increasing elevation of his own energies which his rational consciousness, under the increasing influence of Christianity, secures for him, and which constitutes civilisation properly so called—will at length be enabled, if not continuously to inhabit, at least to (connect and) appropriate for his benefit every portion of the earth's surface; and so to fulfil his Creator's reiterated command "To be fruitful and multiply, and replenish the earth, *and subdue it;* and have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth."

7. When man in a proper spirit avails himself of that dominion over the plants and animals of the globe, bestowed upon him by his and their Creator, he is fulfilling consciously a divine law, similar to, but of higher import than, that law in virtue of which the instinctive consciousness of the animal guides it in availing itself of the vegetables and animals which have been provided as its proper food.

8. It may not be out of place here to remark, that the instinctive consciousness possessed by man, that the majority of the vegetables and animals which surround him would, under circumstances of privation, afford him subsistence, is in exact accordance with the revealed Record, in which we are informed that man after his creation, and again after the flood, was divinely informed by his Maker, that the dominion over

every vegetable and animal which had been conferred upon him involved the legitimate use of them for food—"To you it shall be for meat." "Shall be meat for you."

9. But in as much as man is thus privileged as to the extent of the resources of food allotted to him, the actual extent to which he is to avail himself of that privilege, in ordinary circumstances, would appear to be indicated to him.

1*st.* In his (greater) instinctive tendency to employ certain vegetables and animals for his subsistence.

2*d.* In his preference more particularly for those animals and vegetables, which doubtless were created for his special use as food—*e.g.*, the ox and sheep, wheat and barley;—and the employment of which as food was probably one of those direct Divine communications with which man has been favoured.

3*d.* In his rational consciousness, in virtue of which he is enabled if he will, not only to obey the healthful impulses of his higher instinct, but also to attain, through science, such information regarding the laws of his corporeal constitution, and the various modes of sustaining it, as will guide him to the selection and preparation of food suitable for every district of the earth, season of the year, and circumstances of society, on which his lot may at any time be cast.

10. The same principles by which we have been guided in our examination of the mode in which man, in contrast with the animal, is enabled to supply himself with food over his extended geographical area, would guide us to corresponding results in reference to the methods by which he provides for his protection from influences detrimental to life, from the detrimental effects of heat, cold, dryness, moisture, darkness, unsuitable atmosphere, and other cosmical conditions. We should find a similar combination of original instinct, direct Divine communication, and the application of applied science. We should find the instinctive resources for personal covering

and habitation develope under the influence of man's rational consciousness into all those manifold arts by means of which he is clothed, housed, warmed, lighted, and provided with all those co-ordinated social and civic arrangements which result in the economics of the house, hamlet, farm, city, and state. The latter arrangements compel man, collected in masses, to develope for himself, on instinctive and scientific grounds, the sanitary regulations which such circumstances force upon his attention. But even in our present so-called civilized condition, man shows himself in many respects behind the animal in his sanitary arrangements and precautions. The animal never disobeys, if left to the guidance of its own instincts, the physiological laws of its economy. It is a perfect sanitarian. Our present so-called civilization has only reached the phase of sanitary reform.

11. But man, like the animal, not only finds his subsistence in his geographical area, but also reacts upon it. Here, again, we find that the purposes served by the animal are to a great extent secondary in importance. It merely co-operates in that series of phyto-zoological, or organic actions, which, along with the cotemporaneous cosmical or inorganic processes, tend at any time to prepare the surface of the globe for the reception of man, or maintain it in a condition fitted for his economy. The changes effected by human agency on the surface are of a much more positive kind. The clearing of forests, the recovery of dry surface by coast and river embankment, and by draining, the securing of moisture by irrigation, are processes which not only prepare the surface for agricultural produce, but induce at the same time an appropriate change of climate. The changes of surface and climate, induced by human agency, tend to check the productivity of certain vegetable and animal forms; or by entirely removing their proper conditions of life, cause the local or general disappearance of others. The formation of roads, of bridges, of

aqueducts, of canals, of railroads, of telegraphs, merely presents successive phases of that development of the surface of the globe due to man—a development which is affected under his self-conscious or rational agency, in obedience to his Maker's command "to replenish the earth, and subdue it." It may here be observed, that while the animal is merely enabled, with its specific physical strength, to provide its means of subsistence ; man is enabled as he advances in his work of subjugating the earth, to avail himself of external material force to effect his successive purposes. Under the guidance of his rational intelligence, he proceeds on mechanical principles, he collects and concentrates for the ends he has in view, the forces involved in gunpowder and steam, and thus making his way into the interior of the earth in search of its mineral wealth, modifies its surfaces, in accordance with the requirements of each locality. It must be quite clear to every unprejudiced thinker that human agency is destined to effect extraordinary changes in the arrangements and aspect of the surface of the globe.

12. The proper conception of the nature and effects of those cosmical changes induced by man, may be indicated in the following considerations :—

1*st*, That the full development of man's material economy and welfare on earth, is only secondary to the higher purposes of his existence.

2*d*, That the full development of man's material economy and welfare, including his full legitimate enjoyment thereof, is to be worked out by him in evidence of the amount of knowledge to which he has attained of the laws of God in nature, of the extent to which he has properly applied and enjoyed that amount of knowledge to which he has attained, through the gift of that rational consciousness conferred on him as a part of his human constitution. This principle involves the proper use of man's intellectual faculties and

æsthetic endowments in the cultivation, application, and enjoyment of the arts and sciences.

3*d*, That the knowledge of the laws of God in nature, and the pleasure felt in the proper contemplation and application of them, are merely the adjuncts and aids to that higher purpose of man's creation; his continuous retention of a knowledge of, and his obedient submission to God's moral law, as involved in the principles of Christianity.

14. The human constitution then involves in itself, and secures for man, two guiding principles of action, not possessed by the animal—the faculty of thought, and the moral faculty—in virtue of both of which, but primarily of the latter, he is fitted to fulfil the conditions of a religious being.

15. *Finally*, the economy of man would be incomplete, his various endowments could not be efficiently applied by him, were he destitute of speech. The varied and ever varying development of language is one of the most remarkable results of the peculiar constitution of humanity. To this important subject, as also to other subjects briefly alluded to in the previous part of this lecture, I shall have to recur in subsequent parts of the course; and more particularly in my three concluding lectures, in which I shall have to sum up the results arrived at in the comparative anatomical portion of the course.

16. Such, then, are the conditions of man's life and welfare. In my last lecture we found the conditions of the animal's life and welfare were secured for it, in the fixed and unalterable working of its instinctive form of consciousness. We shall now find that man, provided like the animal with instinctive, corporeal, and cosmical conditions of life and welfare, has superadded to his animal constitution a conscious principle, possessed of entirely different faculties and endowments. In the possession of this higher principle, man is elevated above his own corporeal and instinctive in-

dividuality. He may control his animal instincts, and use his body as a thoroughly adapted instrument. In the possession of this higher conscious principle, a human being is not merely an individual—as an animal can only be considered —he possesses also a personality—he is a person who is called upon to employ not only his body and animal principle, but also his higher or self-conscious principle, conjointly under the guidance of the latter, to those great and extensive purposes for which he was created.

17. From whatever point of view we compare man with the animal, *e.g.*, if we compare, as in the present course of lectures, the anatomical structure of man and the animal, we must keep steadily in view the nature of man's higher conscious principle. I shall have to make frequent reference to the subject in subsequent lectures ; at present, I shall merely indicate the more important features of its economy.

18. In the first place, we are conscious of a faculty of thought, in virtue of the processes of which we reach certain conclusions, not only regarding external objects, but also regarding our consciousness itself. We are conscious in thought of a faculty of judgment. It involves a comparison and a judgment regarding two things, neither of which we can think down or out of existence. The self which thinks, and the self which is thought of. Again in our consciousness in the act of perception, we are not only conscious of *self*, but of a *not self*. We can neither disbelieve the one nor the other. We cannot think unless under the conditions of time. There is always a judgment of *self*, and of *not self*, as existing in time. Time is only apprehensible to us, as a condition under which we think. Hence our human conception of duration.

In the same manner, space is to us only a condition of thought. We can form no conception of it, unless when passing a judgment regarding the relation of things as

they are in it. Hence, likewise, our human conception of motion.

In like manner we are compelled by the constitution of our consciousness to conceive of matter as not annihilable. We cannot conceive of matter as being expanded or compressed in space to annihilation.

The irresistible judgment of casuality too is passed by our consciousness, by virtue of the necessity it is under of judging of existence, under the condition of time.

We cannot think of a thing but as an existence. We cannot think of a thing except under the condition of time; that is, we are under the necessity of considering it as only a new form of what existed before it. Therefore we cannot think of it as absolutely commencing *per se*. We are obliged to conclude with Sir William Hamilton :—"The creation of a world! this, indeed, is as easily conceived as the creation of an atom. But what is our thought of creation? It is not a thought of the mere springing of nothing into something. On the contrary, creation is conceived, and is by us conceivable only as the evolution of existence; from possibility into actuality by the fiat of the Deity."

The human consciousness is therefore self-conscious. By means of this self-conscious property it is constantly compelled to regulate its judgments and beliefs according to certain conditions of its own constitution, as these conditions have been imposed upon it by the Creator of the universe; and which, if adhered to, infallibly lead man to correct results in his inquiries into those departments of science on which so much of his material welfare depends. We find in this self-conscious endowment of the human mind that faculty which supplies man with a mind higher than, and entirely distinct from, the instinctive consciousness of the animal.

In comparing the emotions, appetites, and desires in the human self-conscious constitution with the corresponding

affections of the mind in the animal, the nature of the difference which must exist between those emotional affections in man and the animal becomes evident.

The will in man also is, in consequence of his self-conscious faculty, a will properly so-called, for it is, or ought to be, determined or regulated by those higher or Divine principles of thought and belief of which he is conscious.

At this point we reach the solution of the question as to the essence of humanity. With an animal body and instincts, man possesses also a consciousness involving Divine truth in its regulative principles. But along with this highly endowed consciousness, the human being has been left free to act either according to the impulses of his animal, or of his higher principle. The actual history of humanity, of its errors, its sufferings, and its progress, is the record of the struggle between man's animal and Divine principle, and of the means vouchsafed by his Creator for his relief.*

* The subjects discussed in this and the preceding Lecture, are, in some of their relations, treated with greater fulness in Note VII. to the Lecture on "Life and Organisation."—Eds.

LECTURE III.

THE ERECT POSITION IN MAN.

1. Having endeavoured in my two previous lectures to lay before you a brief outline of those fundamental distinctions between animality and humanity, which must be kept in view in the discussion of every anthropological question, I now proceed to the consideration of certain features which essentially distinguish the human body from that of an animal.

2. I shall devote the present lecture to the illustration of those human structural arrangements which fulfil the conditions of that erect posture peculiar to man.

3. Of the numerous attitudes in which man can sustain his centre of gravity, on one or both limbs, I select as the simplest form of the problem the normal or erect position, properly so-called, introducing occasional illustrations of other attitudes. The erect position is that in which the body is placed when all the parts are arranged so as to occasion the least amount of exertion. In it the spine is erect and the eyes look horizontally forwards, the arms being pendulous. It is the position in which the body is conceived to be placed by the human anatomists in their descriptions.

4.—*The Vertebral Column.*

The human vertebral column is specially arranged for the erect position in man, and presents the following peculiarities, which constitute certain of those adjustments which collectively provide for that position.

a. In the normal position of the human body the axis of

the vertebral column is vertical. No animal form of vertebral column can be elevated into the perpendicular position. In apes, in the so-called upright position, the axis is oblique; and when these animals are on all fours, nearly horizontal. In birds, also, it is oblique. In quadrupeds, horizontal.

b. In no animal form of vertebral column is the column itself cut by its own axis in five points as in the human column. In no animal does it pass through a greater number than four. The axis of the human spine is therefore peculiar in passing across it so frequently.

c. In no form of animal vertebral column are the secondary curvatures so highly developed as in the human, and no animal possesses the lumbar curvature. As the development of the fœtus advances, the spine loses its primary embryonic curve and becomes straight, excepting a slight bend at the coccyx: this is the case even in the child at birth. The curves which appear in the human spine after birth are new or secondary curves. The corkscrew curve of the tail of the spider-monkey is probably an original elementary curve. In the human spine, the neck is convex forward, the dorsal region convex backward; lumbar forwards, sacro-coccygeal backwards. There is also a series of lateral curvatures—dorsal region convex to right, cervical and lumbar to left, sacro-coccygeal to right. If the lateral and antero-posterior curves are connected together, they resolve themselves into a corkscrew-like curve; not the curve of a thread running regularly round a cylinder, but arranged so as to increase or diminish in their course. In disease these curves increase; dorsal to right, cervical to left, lumbar to left, sacro-coccygeal to right. The anterior faces of the bodies of the vertebræ in the dorsal and sacro-coccygeal regions, are consequently inclined to the right; in the lumbar and cervical to the left. No animal has such a spiral development as the above. In fish, the only trace of the fundamental curve is the turn-up of the tail, and probably some

curvature at the base of the skull. In the monkey's neck the convexity of the curve is forwards (downwards), in the dorsal region and loins a continuous curve backwards (upwards), whilst the sacrum is feebly curved, and the coccyx greatly. The non-possession of a separate lumbar curve by animals is a very remarkable fact; in the proper monkeys no such curve exists. Lateral curves are feebly marked in the animal spine.

d. In no animal does the sacrum develope so much in the transverse direction, nor present so large an area of articulation for the haunch, nor become so much curved as in man.

e. The centres of gravity of the human trunk and body, respectively, in their normal erect positions, are situated, the former in the ninth dorsal vertebra, the latter in the interior of the canal of the second sacral vertebra. By the term body is meant the entire frame, trunk, and limbs. Movements of the heart, changes in the circulation of the blood, in the liver, etc., slightly affect the position of the centre of gravity. In no animal can the centre of gravity be in these positions—it must be situated below the vertebral column.

f. In none of the mammalia do the articular facets of the vertebral column possess such surface curvatures as to admit, throughout its pre-sacral portion, that amount of torsion possessed by the ascending portion of the human spine.

g. No mammal possesses vertebral and trunk muscles so fully differentiated, and so spirally arranged as in man. The muscles of the trunk, obliqui, serrati, etc., are arranged in continuous corkscrew-like spirals around the body, as was first pointed out by E. Weber. The peculiar spiral attitudes into which the human body can be thrown are explained by the spiral curve of the vertebral articular surfaces, and the spiral arrangement of the muscles.

h. No mammal can throw its trunk into those spiral curves which subserve the balance of the human frame, and

confer the peculiar grace and expression of its movements. Progression in the human body costs less labour than in the animal. All man has to do is to bend his body forward, and then bring his pelvis forward by muscular action, the exertion requisite to do which is determined by the peculiar pendulum-like movements of the lower limbs.

5.—*The Haunch.*

a. The shafts of the human iliac bones are short and massive; and the direction of their axes is altogether peculiar. They are vertical, and in front of the line of gravity. In the animal they are elongated, oblique from above downwards and backwards, and in addition are situated behind the line of gravity. The axis of the human ilium is very important, because the weight of the trunk is borne upon it.

b. There are five parts in the haunch-bone of the mammal —viz. the sacral articular facet, the pubic symphysis, the ischial tuber, the anterior superior spine of ilium and the acetabulum, which, considered in regard to their relative positions, are quite peculiar in man. The line joining the sacral articular facet, and the acetabulum, is the axis of the iliac bones; the remaining three points form the angles of a nearly equilateral triangle, to which and to the sides and surfaces of the triangles, the muscles which balance the trunk on the thigh-bone are attached. The sartorius, gracilis, and semi-tendinosus, are the three muscles which are connected to the angles of this triangle, muscles which are of great importance in balancing the body when standing on one leg. The human haunch-bone is the only form of haunch-bone adapted for the erect position. It is a lever of which the hip-joint is the fulcrum, the sacral facet representing the extremity of the arm for the resistance, the pubic symphysis, the ischial tuber, and the anterior superior spine of the ilium, the extremities respectively of three arms for the power.

c. The vertical direction of the axis of the iliac bone is due to the lumbar and sacral curvature, and to the promontory.

6.—*The Thigh.*

a. The human thigh-bone is relatively longer and more massive than in any animal form.

b. In no animal thigh-bone is the neck so elongated and so oblique as in the human.

c. In no animal thigh-bone are the areas for the attachment of its proper muscles so limited in extent, but at the same time so precisely expressed as in the human femur. The linea aspera is only met with in its proper form in man, and is to be regarded as an area, not as a mere line. The concentration of muscular attachments on it is a necessary provision for freedom of movement at the hip joint.

d. The human femur is the only thigh-bone which can be extended beyond the line of axis of the vertebral column.

e. The hip-joint can only be fully extended in man, and in man only does it become immovable in its extended position. All animals can fully flex the hip.

f. The human hip-joint is the only hip-joint in which the extensor area is fully developed. Extension may take place from 140° to 160°, according to the mass of muscle which is interposed. This complete movement of extension at the human hip-joint is not due to any laxity of structure, but to the presence of a posterior or extensor area on the head of the femur. In apes and quadrupeds this extensor area is much more feeble than in man; in birds it is scarcely to be seen.

g. The proper muscles of the thigh are in man principally devoted to the balance of the trunk on the hip-joint. The corresponding muscles in the animal are chiefly devoted to the propulsion of the body.

h. The extension of the human femur beyond the line of

the axis of the spinal column is due to the vertical direction of the shaft of the iliac bone, along with the complete extension of the hip-joint.

7.—*The Leg.*

a. In no animal are the tibia and fibula collectively so fully developed and adapted to the actions of the foot, as in man.

b. In no animal can the leg be extended into the line of axis of the thigh.

c. The human knee-joint is the only knee-joint which admits of complete extension.

d. It is the only knee-joint provided with a complete extensor area.

e. No form of leg presents extensor muscles so powerful as the human.

f. The massive flexor muscles of the human leg act mainly on the trunk.

8.—*The Foot.*

a. The human foot is a plantigrade foot.

b. The plantigrade foot in the animal is so constituted that its five digital columns (axes) are more or less uniformly engaged in the actions of the foot itself. In the human foot, again, its four outer digital columns play a subordinate part, while the inner column, that of the hallux, becomes the axis of the foot itself.

c. The four outer or subordinate columns of the human foot are arranged in two groups—the second and third forming the inner group next the hallux; the fourth and fifth the outer group.

d. The human foot has, moreover, its constituent bones arranged in two longitudinal series, or compound columns. The outer column, commencing behind, below, and externally at the heel in the calcaneum, terminates in front and exter-

nally in the three outer toes. The inner column, commencing behind, and above, and on the inner side in the astragalus at the ankle, terminates, in front and inwards, in the hallux and second and third toes.

e. The integument of the sole of the animal plantigrade foot presents a pad for the heel, and pads below the metatarso-phalangeal joints. The sole of the human foot has three pads only, one for the heel, the other two corresponding to the metatarso-phalangeal portions of its two composite columns. The sole of the human foot is therefore peculiar, in presenting a strongly marked integumentary groove or fold indicating the distinct action of its two columns (Fig. 13).

f. A line, extending from the outer part of the back of the heel to the point of the hallux, indicates the dynamic or proper axis of the human foot.

g. In full extension of the ankle-joint, along with longitudinal curvature of the dorsum of the foot and complete extension of the great toe, that portion of the axis of the foot behind the great toe, may be brought almost in a line parallel to the line of gravity. No animal foot permits of such an amount of extension.

h. The human foot is a tripod, the heel and inner pad being its fixed points, the outer pad the adjustable point.

i. The human ankle joint is the only complete ankle joint; it alone possesses a complete extensor area.

j. In man alone is the astragalus permitted by the completion of its articular connections with the calcaneum, scaphoid, and cuboid, to determine those delicate rocking and oblique movements of the human foot, which condition also the varied inclinatures of the limb and body on the foot.

k. The structure in the ape corresponding to the human foot is a foot-hand, or *manu-ped.* Presenting the fundamental type of the foot of the mammal, it is so modified as to form a clasping instrument. In certain respects it more nearly

resembles that only perfect hand, the human hand, than the so-called hand in the anterior limb of the ape itself.

l. The ankle-joint of the ape is so arranged as to throw the sole of the foot inwards, hence the ape walks on the outer margin of the foot.

m. In man, while the muscles which act on the toes are fully differentiated, and precisely adjusted, they are comparatively weaker than those of the ape.

n. The deep or primary muscles of the ankle in the ape are comparatively stronger than in the human subject. The secondary extensors of the ankle in the ape are comparatively feebly developed. In man again they assume their complete form, and constitute the mass of the human calf.

o. You are now in a position to perceive the nature of those arrangements in the human body, by which the erect position of man is conditioned. These arrangements essentially consist in a completion of those facets on which full extension of the lower limbs depends, and on the due coordinated curvature of the vertebral column. They are all of a nature involving the conception of absolutely complete structure, and they also involve, as I shall show more at large in my next lecture, highly important relations to the rational consciousness in humanity.

LECTURE IV.

THE UPPER LIMB IN MAN.

1. The evidence adduced in my last lecture is, in my opinion, amply sufficient to prove that the erect attitude, in contradistinction to what I must now term the semi-erect attitude in certain animals, has been conferred on man alone.

2. The erect attitude in man is the principal condition of that high privilege which he enjoys of the free use of his upper limbs, in the performance of higher functions than the locomotory.

3. The upper limbs in man are the immediate instruments, under the guidance of his rational consciousness, of that power with which he is invested over material nature. Set free by the peculiar construction of his lower limbs and spinal column, and presenting a peculiar organisation of their own, his upper limbs act freely in all those relations of space involved in the human conception of matter.

4. The upper limbs, like the lower, consist of a proximal element—the shoulder, an intermediate element or shaft, consisting of the upper arm and fore-arm—and a distal element—the hand.

5.—*The Shoulder.*

a. The fundamental peculiarity of the human shoulder consists in the direction of its axis, which is a line extending from the body of the fourth dorsal vertebra to the upper area of the glenoid cavity; and traversing, therefore, the body of the coracoid portion of the scapula. The shaft of the scapula

is inclined outwards and forwards against the axis of the shoulders, and meets it in the glenoid cavity. The shaft of the clavicle inclines much more backwards against the shoulder axis, passes above it, and abuts against the acromion, above the glenoid cavity. The axis of the shoulder is therefore at right angles, not only to the axis of the spine, but also to that of the haunch (Fig. 1).

b. On the other hand, the axis of the shoulder of the animal is oblique, not only towards the hæmal aspect, but also towards the cephalic extremity of the axis of its spinal column; that is, in an opposite direction to the obliquity of its haunch, which is oblique towards the coccygeal extremity of the spinal axis (Figs. 2, 3, 4, 5). The quadrupedal scapula is so oblique that the anterior ends of the two bones approach one another anteriorly. These obliquities are of importance in the animal economy. In the shoulder of the horse, for example, the more oblique the scapula the better adapted is the animal for speed. The scapula is the chief bone of the shoulder, as both the coracoid and clavicle may for the most part disappear.

Fig. 1.
1. Axis of trunk.
2. Axis of haunch.
3. Axis of shoulder

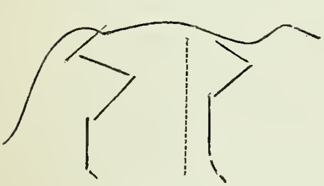


Fig. 2.

Outline diagram of a Quadruped.

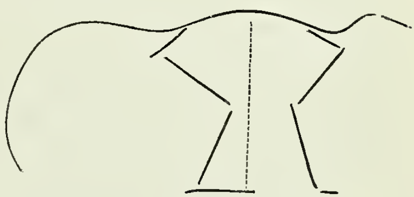


Fig. 3.

Outline diagram of a Monkey when in the horizontal position.

c. The anatomical conditions which determine the antero-posterior and transverse obliquities respectively of the shoulder in the animal are:—

1st, For the antero-posterior obliquity—the upward curv-

ature of that portion of the neck from which the limb is developed. This is about the lower cervical and upper

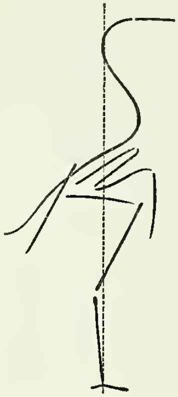


Fig. 4.

Outline diagram of a Bird.

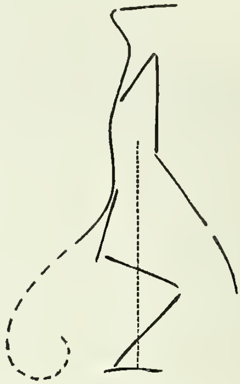


Fig. 5.

Outline diagram of an Ape in its so-called erect position.

dorsal region, and the limb is developed at right angles to the vertebral axis. In man there is not such a curvature backwards of the lower part of the neck as in the other mammalia.

2d. For the transverse obliquity—the lateral compression of its thorax—which again, by bringing the quadrupedal scapulæ close together anteriorly, constitutes one of the conditions of the locomotory function of the limb.

d. The human scapulæ lie on the neural aspect of the thorax ; the scapulæ of the animal on its lateral aspects.

e. In no animal does the scapula present platelike expansions and margins, comparatively so extended as in man, and in no animal are the spine of the scapula and the acromion so fully developed as in man.

f. In no animal is the coracoid portion of the scapula proportionately so fully developed as in man. The coracoid process is comparatively more massive and curved in man ; and in addition, the coracoid portion of the glenoid articular surface, which carries the humerus in full extension, is only fully developed in man.

g. The scapula and clavicle are more harmoniously developed in the human than in the animal shoulder.

h. The strongly marked sigmoidal curvature of the human clavicle, and the peculiar curvatures of the scapular spine and acromion, are related to the transverse and horizontal direction of the axis of the shoulder ; for no animal has the acromial extremity of the clavicle fully developed, nor can the axis of the acromial portions of their opposite clavicles coincide with a common transverse line. The coincident transverse line of the opposite acromio-clavicular axes in man lies above the axes of the shoulders, and is parallel to them.

i. The peculiar carriage of the human shoulders (the square shoulder) is due—

1st. To the position of the scapulæ on the posterior (neural) aspect of the trunk.

2d. To the rectangular relations of the axes of the shoulders to the axis of the trunk; and

3d. To the curvatures of the clavicles.

k. The movements of the human shoulder are—

1st. Rotation from behind forwards, and from before backwards, with the clavicle as a radius.

2d. Rotation from below upwards, and from above downwards, also with the clavicle as a radius. These two rectangular movements are so co-ordinated that each rotation may take place, more or less freely, in any given angular position of the other. The primary plane of the antero-posterior movement is the horizontal plane of the shoulder; and the primary plane of the movement from below upwards, is the transverse vertical plane in which the axis of the shoulder lies.

l. As contrasted with the movements of the human shoulder, we find that on account of the transverse obliquity of the areas of the shoulder in the mammal, and the lateral position of its scapulæ, along with its horizontal attitude, the vertical rotation in man becomes an antero-posterior in

the animal; and the antero-posterior in man not only becomes an inward rotation, but is much diminished in extent in the apes, and is all but eliminated in the typical quadruped.

6.—*The Arm.*

a. The shaft of the upper limb in man, like that of the lower limb, is much more harmoniously developed as regards their lengths respectively to one another, to the length of the trunk, and to the lengths of thigh to leg, and of arm to fore-arm, than in the animal. The shafts of the human limbs are longer in relation to the trunk than in the animal.

b. In the pendulous position of the human arm, its axis is at right angles to the axis of the shoulder. This may be termed the vertical position, or position of passive flexion. By muscular action it may be carried before or behind the trunk to about 30° beyond its vertical position; in such positions it is in full flexion. It cannot be extended appreciably beyond the level of the axis of the shoulder without moving the scapula. From its fundamental extended position, in which it is in a line with the axis of the shoulder, it can be swept in rotation horizontally forward to about 30° nearer the mesial plane than its vertical position, and to the same extent in successive depressions or degrees of flexion, so far as the interposition of the trunk will permit, on to extreme flexion.

c. No animal can fully extend the shoulder-joint—that is, bring it in a line with the axis of the shoulder. The amount of deficiency in flexion is equal to the angle of antero-posterior obliquity of the shoulder. And again, in proportion to the increase in transverse obliquity, is the limitation of the movements of the shoulder at right angles to the plane of flexion and extension.

d. The distinct specialisation, and the great development of the deltoid in man, is in direct relation to the perfection

and extent of the movements of his shoulder-joint. In full extension there is a complete rotation of the humerus on its axis when the palm is turned upwards, which is due to the spiral twist of the bundles of the deltoid. On the surface of the head of the human humerus is a distinct area devoted to the movement of extension, which corresponds to the extension area of the femur. The larger figure (Fig. 6)

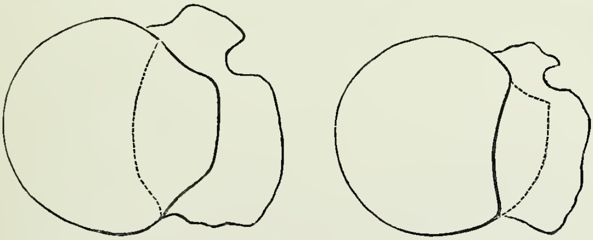


Fig. 6.

is the head of the human humerus, the smaller that of the ape. The space lying immediately to the right of the dotted line in the former is the articular area for complete extension which is absent in the ape's humerus. The coracoid area in the glenoid cavity is the extensor area of that aspect of the joint.

e. The shoulder-joint in man is alone provided with complete articular areas.

7.—*Forearm.*

a. No animal, not even the ape, can either fully extend or fully flex the elbow joint; nor is any animal capable of completing the movements of pronation and supination.

b. In the ape, the flexor articular areas are less complete than the extensor, the movement of extension being especially required in swinging from tree to tree; and the groove between the radial head of the humerus and the trochlea, instead of being nearly direct, as in man, takes the double oblique course of the ulnar trochlea. The articular surface for the radius is confined to the anterior surface of the human humerus, so that it is in the flexed or semi-flexed position

that the movements of pronation and supination are most exactly performed. In the ape, the radial articular surface extends further backwards, so that it takes a share in the flexion and extension movements of the elbow joint.

8.—*The Hand.*

a. I shall confine my comparison of the human hand to the so-called hand of the ape; and for the purpose of bringing before you in a distinct manner the principle which determines the construction of the human hand, I shall confine my statements to such features of its structure as bear directly on that principle.

b. The human hand is the only perfect or complete hand. In no other is there such a freely moveable thumb, capable of such complete opposition, which is provided for by the saddle-shaped surfaces of its carpo-metacarpal joint. The opposition of the thumb must be distinguished from the apposition of the great toe, the tarso-metatarsal joint of which admits of movements in one plane only. The peculiar obliquity of the metacarpo-phalangeal joints of the four fingers must be noted; those of the index and middle extend downwards into the palm towards the thumb; that of the ring partially, and that of the little considerably downwards, and towards the ulnar side of the palm. It is owing to this that the little finger possesses the power of being opposed to the thumb. When the hand is clenched, the points of the fingers tend to the radial side. In the skin of the palm certain folds may be seen, which are indicative of the effects produced on the skin by the movements of the joints. 1st, the great oblique fold for the thumb. 2d and 3d, two oblique

Fig. 7.

Outline diagram of the skeleton of the human hand. The dotted lines indicate the direction of the movements at the metacarpo-phalangeal joints.

folds, the proximal from the radial to the ulnar sides; the distal from the ulnar to the web of the 2d and 3d digits.

Fig. 8.
Palm of human hand, showing the direction of the great tegumentary folds.

The human hand may be hollowed into a cup, and it can grasp a sphere. It is an instrument of manipulation co-extensive with human activity.

c. The hand of the ape is an imperfect hand, with clearly defined points of difference and inferiority, when compared with the human hand. Its thumb is short and feeble, and the axes of the metacarpo-phalangeal articulations of the fingers are inclined towards the thumb. It can embrace a cylinder, as the branch of a tree, and is principally subservient to the arboreal habits of the animal. Its fingers grasp the cylinder in a series of spirals. The proximal and distal grooves

on its palm are transverse, and not oblique. There are also radiating grooves, commencing at the carpal end of the palm.

d. The human hand and the hand of the ape are not only hands when viewed morphologically, but they are also hands when considered from the teleological point of view.

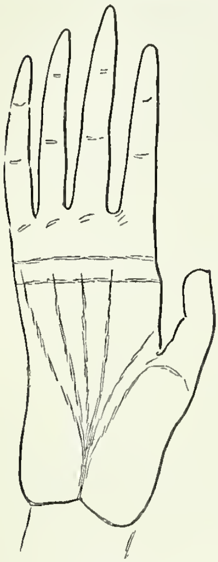


Fig. 9.
Palm of ape's hand, showing the transverse and radiating tegumentary folds.

e. The human foot and the ape's foot are morphologically feet, but the human foot is not only morphologically but teleologically a foot; and, moreover, the only perfect and complete foot, whereas the ape's foot is teleologically a hand. The metatarso-phalangeal joints of the human foot all incline outwards from the great toe, due to the direction of the pressure upon them. This outward inclination gives breadth to the foot. In the foot of the ape the metatarso-phalangeal joints all incline in the same direction as the metacarpo-phalangeal joints in its hand. The foot is consequently clenched like a fist. In the sole of the human foot there is a great longitudinal groove, commencing in front of the heel-pad, which is the tegumentary indication of the double-columned arrangement. In the sole of the ape there is a longitudinal groove which comes out on the outer side of the great toe, and corresponds to the thumb fold of its hand.

Fig. 10.
Outline diagram of the skeleton of the ape's hand. The dotted lines indicate the direction of the movements at the metacarpo-phalangeal joints.

9. As man enjoys the privilege of a complete and independ-

ent use of his lower limbs, he has in like manner (and to a certain extent conditioned by his erect attitude) a completely developed upper limb.

Fig. 11.

Outline diagram of the skeleton of the human foot, showing the outward movement at the metatarso-phalangeal joints.

Fig. 12.

Outline diagram of the skeleton of the ape's foot, showing the inward movement of the metatarso-phalangeal joints.

10. The principle on which the completeness of the upper limb in man is based consists in its purposes as an instru-

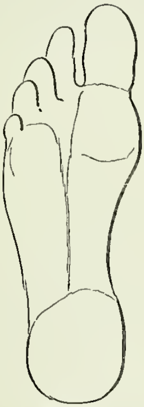


Fig. 13.

Sole of the human foot, showing the great longitudinal groove.

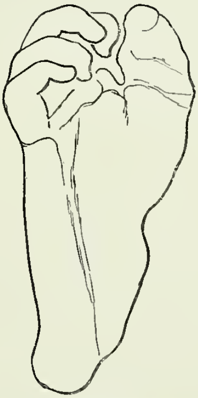


Fig. 14.

Sole of ape's foot, showing its longitudinal groove.

ment for acting on matter, in terms of his human faculty of thinking in space. His erect attitude gives him *reach* in

length ; his power of extending his shoulder joint reach in breadth ; by means of his hand he can grasp in all the relations of space.

11. Finally, in reference to completeness of the human skeleton with the joints and muscles, man is not only alone in his erect position, but he alone can lay himself in the prone and the supine positions. This he is enabled to do by the antero-posterior compression of his thorax.

LECTURE V.

THE INTEGUMENT AND ORGANS OF SENSE AND SPEECH IN MAN.

1.—*The Integument.*

a. It would appear to be essential for the economy of every kind of organism that the general mass of structure should be invested by an integument.

b. The integument may serve as a means of preserving the general form, as a protection from external influences, as an excretory apparatus, as an absorbent medium; and, lastly, as an arrangement for placing the nervous system in relation to external objects.

c. All these functions of the integument are brought more or less prominently into operation by special modifications of structure in the animal kingdom. But in no animal do we find the integument so harmoniously developed, for all its special ends, as in man.

d. In no animal is the sub-cutaneous fatty tissue comparatively so coherent and elastic as in man; nor in any animal is it disposed so as to afford that strongly-marked but softened display of the form and movements of subjacent parts, which contributes so much character to the human form.

e. Like the general muscular system, which is fully specialised in man, the cutaneous muscular system, or panniculus carnosus, although of comparatively limited extent, is also fully specialised, and, in this respect, distinguished from the corresponding system in the animal. No animal presents

that complete specialisation of the cutaneous muscular arrangements of the head and neck, which completes the mechanism of the eyebrows, eyelids, nostrils, cheeks, lips, chin, and neck in man; and confers on him that power and extent of corporeal expression which he alone possesses.

f. The human skin is remarkable for its combined density, toughness, and pliancy. In no animal are the arrangements for permitting the necessary foldings of the skin during the movement of the body so elaborately carried out as in man. These folds are permanent arrangements co-ordinated with the movements of the subjacent parts, and divide the skin into areas of greater or less extent. They are developed in their greatest complexity in the face, hands, and feet; also around the joints. Although specific in their character, they vary from individual to individual, but so precisely are they co-ordinated with subjacent parts, that individual differences in the conformation of such parts may be safely assumed from observation of the folds of the enveloping skin.

g. The oil-glands of the human skin, although widely and elaborately distributed, do not distinguish it in so marked a manner from the skin in the higher animals, as the system of sweat glands; which latter appear to reach their complete development, and most extended distribution, in man.

h. The semi-transparent and iridescent character of the cuticle in man contributes largely to the characteristic aspect of the human body.

i. The distribution and character of the hair in man is highly characteristic, and indicative of the distinct and peculiar nature of his economy. In the higher animals, hair is provided for protection and warmth. It serves more varied ends in the human economy. That protection and warmth, which is directly provided for the animal in its hairy covering, is left to be provided for the human body by its indwelling intelligence. That sex which, by the very constitution of

humanity, is most exposed to external influences in the accomplishment of his daily labour, is provided with a covering for head, face, trunk, and limbs, sufficient to afford that kind and amount of protection which the nature of his economy requires in the varied circumstances of climate and occupation. To a certain extent, and co-ordinate with her conditions of life, integumentary arrangements of a similar kind are provided for the other sex. These protective arrangements of the hair in man are, however, altogether subordinate. The principle which determines the distribution of hair on the human body, appears to be based on the higher form of the emotional and æsthetic phases of the human constitution. The characteristic aspect of the human frame is undoubtedly due in great measure to that peculiar variation in the hair development of its different integumentary areas ; and no one who considers the subject in all its bearings, can fail to observe the remarkable co-ordination which exists between these corporeal attributes, and the emotional phase of human consciousness. In no animal is the direction or arrangement of the hair so complex as in man.

k. The sensibility of the human skin is its most important physiological feature. No animal displays a cutaneous nervous system so developed as the human.

l. The plan of distribution of the cutaneous nerves of the trunk in man, and the higher vertebrata, is identical. But in consequence of the erect attitude in man, the six rows of cutaneous nerves, two posterior, two anterior, and a right and left lateral, are vertical instead of horizontal. The vertical arrangement of these rows of sensitive skin areas, on the front, sides, and back of the body, are thus specially associated with that erect attitude, which we have already seen to be a necessary corporeal co-ordination with that faculty of the human mind, by which we are enabled to think in space.

m. The human skin is characterised by the precision of its

tactile sensibility, as well as by its full physiological relations to temperature, pressure, and muscular action. In no animal are the tactile arrangements on the distal portions of the limbs so fully developed as in man. No form of ape exhibits the same complex and relatively minute arrangement of tactile ridges as in the human hands and feet. These ridges have centres of evolution and angular points of convergence, as is the case with the hair in other localities. In the human hand, the tactile ridges at the points of the fingers are very complicated, and relatively minute. In the human foot, the great tactile area is on the outer pad of the foot. The sensibility of the human sole is of primary importance in locomotion, as in man two limbs only are employed, and the body is occasionally even balanced only on one foot.

n. Finally, the human integument is directly developed in reference to the intellectual and emotional phases of his constitution.

2.—*Smell and Taste.*

a. The organs of smell and taste in man are distinguished anatomically by their apparent feebleness of development, and physiologically by their much more extended spheres of action.

b. The human olfactory organ is comparatively limited in extent. The upper wall of the nose—the cribriform plate—is parallel to the horizontal plane of the head; its direction being indicated by that of the fronto-ethmoidal suture.

c. The sense of smell in man is apt to be blunted by his habits of life. But although this sense is actually more acute in certain animals for special odours; no animal apparently possesses an appreciation so extensive of odours in general.

d. The structural arrangements which subserve the sense of taste are not confined to the tongue, but extend along the

fauces and palate. All those arrangements in the tongue, fauces, and palate, which adapt those parts to their functions in the process of digestion, adapt them also to the sense of taste. Of the special adaptations of those parts in man, the most important are the great tactile sensibility of the tongue, and the horizontal position of the mouth.

e. There is, probably, no difference in the sense of sapidity, or taste proper, of man and the higher animals, except, perhaps, in its delicacy in man. Animals undoubtedly possess the sense of flavour in special forms. But there are sufficient grounds for assuming that no animal can employ his organs of smell and taste in combination to the extent of appreciation of flavour as it exists in man. Many of the sensations we are in the habit of regarding as due to taste are probably merely modifications of touch. The positive sapidities are probably not more than four or five.

f. The senses of smell and taste, in their isolated and combined effects, are associated with the emotions and appetites in man, to an extent not generally fully appreciated.

g. In the animal both senses are devoted, but in a relatively lower sphere, to certain of their instinctive emotions and appetites.

3.—*The Eye and Ear.*

a. The eye and ear in man being more immediately associated with his higher interests, present special arrangements, having important bearings on the subject of the present course. I cannot, in the time at our disposal, enter at any length into the consideration of the eye and ear in man, and in the animal kingdom. I shall confine myself to-day to certain relations of these organs, which I shall have to recur to in my next lecture, on the head and brain.

b. The fronto-ethmoidal suture in the human orbit is horizontal, that is to say, it is parallel to the axis of the

head. It is inclined to that axis in the animal. The value of the angle formed gives the angular value of inclination of the head. This suture indicates in animals the proper position of the orbit and head; when it is horizontal, the head is in the position of normal obliquity.

c. The human orbit presents three walls, and in like manner, when perfect in the mammalian series, it consists of three walls, the inner, outer, and superior wall. The only orbit in which the inner walls of opposite orbits converge forwards is the human, so that in it only, when the orbits are looked into directly from the front, can the two optic foramina be seen at one time.

d. The planes of the apertures of the opposite orbits in the mammalian series are inclined forwards towards one another, at an angle which increases as the series descends. These planes of the orbital apertures are also in a descending order inclined upwards and inwards. In man the planes of the orbital apertures coalesce. They are transverse and vertical. The margin of the human orbit presents at the same time an oblique double curvature, not observable in the ape or in any lower form. The margin is co-ordinated with the great amount of movement of the human eyeball, especially through the oblique muscles. An inclination of the orbital plane, upwards and inwards, takes place in the mammalian series, but not in man.

e. The human orbit presents the most elongated form, and most extended outer wall.

f. These orbital peculiarities of the human skull are special provisions for a greater freedom and extent of visual directions, but more especially to provide for a more perfect binocular vision.

g. The semicircular canals of the organ of hearing are connected with the sense of direction of sound. They are situated at right angles to each other. No one is situated

precisely right and left to its fellow, or to the axis. The little shelves in the ampullar dilatations at the ends of these canals lie in three rectangular planes to each other. The antero-posterior canal has its shelf horizontal. The posterior has its shelf facing forwards and backwards. The shelf of the external or horizontal canal faces right and left.

h. The horizontal position, which appears essential to the efficiency of the semicircular canals, and is a marked feature in man, is provided for in the head of the animal by the same changes which render its visual axis horizontal.

4.—*Voice.*

a. The human larynx is characteristically simple and complete in its arrangements. Its special characters are the mobility of the arytenoid cartilages, the complex curvatures of the crico-arytenoid articulations, and the total absence of any superadded acoustic arrangement. The perfection of its structure is evinced in the purity of its tones, and the extent of its intonation. The erect attitude in man, by which the lungs are brought beneath, and the air sinuses of the head above the larynx, and, in addition, the vertical position of the organ itself, all conduce to the perfection of the mechanism of the human larynx.

b. The cochlea is apparently the structure which controls the action of the larynx. Both structures are co-ordinated in the most remarkable manner with the æsthetic phases of the human conscious principle. They appear also to be intimately associated, through connections of the ear and the brain, with the higher forms of associated muscular action. In playing on musical instruments, the wonderful power of manipulation which can be attained is not a mere habit. It is due to a positive nervous mechanism connected indirectly with the organ of hearing.

5.—*Speech.*

a. As the instinctive consciousness of the animal provides each individual of the species with the faculty of acting in co-operation with its fellows, the social, or other instrumental signs or signals by which direct intercommunication is effected, are comparatively simple. As human action, again, is essentially dependent on man's rational consciousness, it becomes an important condition of his welfare that a portion of his corporeal mechanism should be such as to supply him with a system of intercommunicating signals co-ordinate with the universality of his conscious acts.

b. As a special modification of the upper end of the air tube is provided as the instrument of voice in man and the mammalia, so in like manner the mechanism of speech is provided for man alone in peculiar modifications of his buccal pharyngeal and nasal chambers.

c. The mechanism of speech is such that certain voluntary dispositions of its parts induce in the air generally, during expiration, certain sounds termed articulate sounds, which may be mute or unvocalised—*i.e.*, unaccompanied by laryngeal action as in the whisper, or intoned as in ordinary speech, which is produced in co-ordination with the voice. It is wrong to suppose that speech is not provided for by the structure of the mouth. No animal has its lips pouting outwards like those of a man, not even the chimpansee, in which the lips are drawn together over the convex rows of the teeth. Man is peculiar in the vertical direction of his teeth, the posterior surfaces of the front teeth being adapted to the tip of his tongue. The human tongue has scarcely any body, only root, tip, and margin. The short-vaulted palate of man is peculiar, and adapted to the dorsum of the tongue. The human pharynx and fauces are peculiar in the shortness and mobility of the uvula, which is the chief framer of vocal sounds. The

upper pharyngeal chamber is very capacious in man, and communicates with the nose; and the frontal sinuses increase the extent of this chamber.

d. Languages vary in the number of articulate sounds involved in their construction. They also vary in their relative preference for certain forms of articulate sounds.

e. Articulate sounds are merely the elements, by the combination of which, the composite sounds, or words, which actually constitute a language are formed.

f. All words are originally appellative—*i.e.*, expressive of general or abstract ideas or conceptions. Words employed as special or proper terms, as also words expressive of relation, are of secondary formation, being derived by modification from the primordial forms or roots, and applied, in the construction of any given language, in a manner determined by the economy of the linguistic group, to which the language belongs.

g. In the course of that remarkable development which language has hitherto exhibited, and which it is undoubtedly destined to undergo in the future, and in which older languages apparently disappear and new languages apparently arise, but in reality only as modified forms of their predecessors; the primordial words or roots themselves become so much modified, that in the more advanced forms of language their presence can only be detected by linguistic methods of research.

h. The number of possible linguistic roots must be determined by the adaptability of the mechanism of speech for their production. The actual number in use in different languages is probably determined—

1st. By the relative difficulty in executing certain forms of them;

2d. By that difficulty in executing certain of them induced by ethnological differences in the mechanism of articulation; and

3d. By the selection of the more appropriate forms.

i. It thus appears that these composite sounds which men originally employed as abstract terms have supplied the roots or primordial forms of all words employed in languages.

k. The same principle appears to determine the process of acquisition of language by the child. The impressions made by external objects on the consciousness of the infant appear to be merely general impressions, as indicated in the terms employed by it to express them. As it advances in its course of self-tuition, and as the special properties of external bodies, and their various relations to one another, and to itself, become recognised by it, it applies terms of a more special and relational character. It thus avails itself, in the acquisition of its mother-tongue, of the same analytical process by which every form of speech has been, and will be developed, and by which, be it recollected, all acquired human knowledge has been attained.

l. It would appear, therefore, that as the roots from which the various classes of words have been derived are expressions of general ideas or conceptions of the different properties, qualities, relations, and attributes, of the objects to which they were originally applied, their original adoption is in accordance with the peculiar constitution of the human conscious principle ; in virtue of which its special processes are conducted under those general modes or forms of thought by which it is fitted for the intellectual and moral ends of human existence. It appears, therefore, incontestable, that the peculiar character of the human consciousness is the fundamental condition of *speech;* and that no animal *talks,* because every animal economy is conditioned by a merely instinctive form of consciousness.

m. As speech therefore is merely thought expressed phonetically, it remains to be considered—

1st. How man has been led to employ phonetic means to express his thoughts ; and

2d. On what principle he made choice of certain radicals to express certain conceptions.

n. Man, like the animal, has been endowed with an instinctive disposition to employ those organs or instruments which are subject to the will. We cannot doubt, therefore, that the employment of the mechanism for articulation is provided for in a co-ordinate instinctive impulse. This instinct however, is only operative when the sense of hearing is sufficient, and the perfect use of its appropriate mechanism can only be attained under the guidance of the ear. The child, through its organs of hearing, is induced and enabled to imitate the articulation and intonation of those around it, and by the same instrumental means it controls and rectifies its own imperfect utterances. Speech, therefore, although based on the conscious principle of humanity, and provided for in an instinctive corporeal mechanism, is actually acquired by a combined course of self-tuition and education.

o. In learning to speak, the child is supplied, through its organs of hearing, with the radicals of its native language, already developed into the grammatical forms of that tongue.

The tenacity with which phonetic types, or root-forms, retain their value in the successive developments of language, is involved in the question as to the principle on which choice was made of a certain type of articulate combination, to express certain conceptions. That such choice was the result of a selection and retention of the most suitable out of numerous provisional forms, appears to be an assumption tending to complicate unnecessarily the entire subject. I myself should be inclined to assume, as a probable solution, that there exists in the human constitution, a co-ordination between the possible articulate combinations, and a special phase of the conscious principle, in the same sense as that co-ordination,

which undoubtedly exists between the physical value of musical notes produced in the larynx, and the æsthetic phase of human consciousness. Behind this fact, however, lies one of the most important questions in anthropology. How was primitive speech acquired? Did primitive man, unassisted, determine in the first place what attribute of a given object should be selected for its name, and thereafter employ the appropriate phonetic sign for that purpose? Did he, fully provided psycho-physiologically for the development of a form of speech for himself, gradually accomplish that task? Or was he, in his peculiar circumstances, supplied with advantages equivalent to that early training which facilitates the acquisition of speech by his successors. I shall reserve what I have to say in reference to these questions for a future lecture; at present, that I may not be misunderstood, I would merely state,

1st, That these questions involve points which cannot be solved by science or history.

2d, That in these, as in all other great questions in anthropology, the conclusions to which we come, or the opinions we may entertain regarding them, ought to be such as have been arrived at by giving due weight to all the evidence, direct and indirect, with which we are supplied; and

3d, That my own opinion, regulated by such principles as I have now and on a former occasion brought under your notice is this—That man is fitted, by his conscious and corporeal constitution, to develope and employ speech, but that the employment of the faculty by the child demands a certain amount of preliminary initiation; and that primitive man, in his peculiar circumstances, was in this, as in other essential elements of his spiritual and material welfare, beneficently supplied with the necessary initiation by an immediate or Divine process or act.

p. Language, when considered as a fundamental endowment of the human economy, and at the same time in its con-

tinuous development in the progress of humanity, presents a double aspect. From one point of view it appears as a human faculty, from another as the result of human art. But strictly it has no place among the works of man. Man has no control over it; he is merely an unconscious agent in its changes and progress. The first actual addition made by man to his faculty of speech is his written language, which has been followed up by all those arrangements by which thought and knowledge are recorded and transmitted through space and time.

LECTURE VI.

SKULL AND BRAIN IN MAN.

1. In bringing under your consideration to-day the relative structural arrangements of the skull and brain in man and the animal, I shall not touch on any of those topics which have recently conferred on the subject a kind of notoriety, at all times adverse to the progress of science, but shall confine myself to points which will supply us with data for the illustration of the special object of this course.

The Skull.

a. The cephalic axis (axis of head) is a right line extending in the mesial plane, from the anterior margin of the occipital foramen, along the floor of the nose to the incisive openings, and prolonged to the cartilaginous extremity of the nose. The floor of the nasal fossæ in man and mammals, until we come low down in the series, is remarkably straight as far as the incisive foramen, at which there is a ridge. The line of the cephalic axis must be taken as a central line, because in the examination of the axis of the spine we found that its axial line came in contact through the axis vertebra with the anterior margin of the foramen magnum. The assumption of a line which shall represent the axis of the cranium involves the idea of its being continuous with that of the spine. The axial line of the head is horizontal. In man alone does this line touch the posterior as well as the anterior margin of the foramen magnum.

b. The cervico-cephalic angle is the angle made by the axis of the spine with the axis of the head. This angle does not exist in the fish and amphibian, in which the axis of the head and spine forms a continuous line. In reptiles, birds, and mammals, this angle is more or less marked, but in none of them does it reach a right angle. In the different mammals the angle varies with the species. In man alone is the cervico-cephalic angle a right angle.

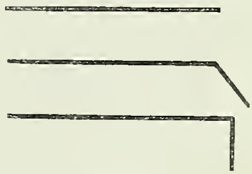


Fig. 15.

Diagrammatic outline of the cranio-spinal axis of a fish, of a reptile, bird, or mammal, and of a man.

c. In man the occipital foramen, and the upper surfaces of the nasal fossæ lie in a horizontal plane, the mesial line of which is the cephalic axis.

In the animal (mammal) again, the occipital foramen and floor of the nose lie in two planes at an angle to one another. The palatal plane, in which the cephalic axis lies, is inclined downwards at the cervico-cephalic angle. The occipital plane is inclined upwards from the palatal at an angle which increases in the descending order of the mammalian series.

d. In man the cribriform plate, and the line of osseous attachment of the tentorium, lie in a plane parallel to the palato-occipital, and therefore horizontal.

In the animal this plane is divided, so that its cribriform and tentorial portions are elevated at an angle which increases with the descent of the mammalian series.

d. The squamous plate of the occipital bone, and the plane of the occipital foramen are inclined to one another in man, at an angle which increases with the development of the cerebellum. This angle, which may be termed the squamo-occipital, increases in the descending series of the mammals.

e. The slope of the basilar process forms, with the line of the cephalic axis, an angle which diminishes as we descend the series. This angle—the occipito-basilar angle—

is important in the investigation of the varieties of human crania.

f. The spheno-basilar angle is the angle formed by the upper surface of the basilar process, and the floor of the Sella Turcica. It increases from man downwards, and is a most important element in the construction of the human skull.

g. The spheno-ethmoid angle is the angle between the anterior sphenoid and the cribriform plates. It exists in man in a more or less developed form; but so that the cribriform side of the angle is, in well-formed heads, horizontal. In the descending animal series the ethmoidal side of the angle rises so as at last to assume the rectangular position.

h. As the nasal bones rise with the cribriform plates in the descending series, the ethmoido-nasal angle diminishes. The extent of the ethmoido-nasal angle is a marked feature of the human head.

i. There are three series of curvatures in the construction of the skull :—

1*st*, The primordial curvature.

2*d*, The secondary or permanent curvatures of the base, which are represented in the series of occipito-basilar, spheno-basilar, spheno-ethmoidal, and ethmoido-nasal angles, and the resultant of which is represented in the cephalic axis.

3*d*, The antero-posterior and transverse curvatures of the vault of the cranium.

k. In comparing the secondary or permanent curvatures of the base of the skull in man and the animal, it is evident that the amount of curvatures is much greater in man than in the descending series of mammals.

Moreover, in the greater curvature of his cranium, man retains in great measure the primordial or embryo curvature, whereas the lower we go in the series of vertebrata, the more completely do the primordial curvatures disappear or become masked.

The greater curvature of the human skull is the fundamental condition of that enormous additional space afforded for the human brain, and also for the relatively abundant space provided for the nasal, oral, and pharyngeal cavities.

We must associate the diminution of the spheno-basilar angle, and the elimination of the palato-occipital angle, with the increased depth of the cerebellar fossæ, with the horizontality of the tentorium, and with the extension backwards, and vaulted form of the parietal region of the cranium, for the reception of the posterior lobes of the cerebrum.

Again we must associate the elimination of the spheno-ethmoidal angle, and the diminution of another angle, the vomerine (to be alluded to in the sequel), with the horizontality of the cribriform plate, and of the orbital plates of the frontal with which that plate is connected, as well as with the vaulted form of the frontal itself; and, consequently, with the great increase in the mass and complexity of the anterior lobes of the human cerebrum. The same peculiarities secure for man the inferior position, and horizontal arrangement, of the nasal chambers, orbits, and oral cavity.

The antero-posterior and transverse curvatures of the vault of the skull, as well as the curvatures of the fossæ on the floor of the cranial cavity, are anatomically conditioned by the surface curvatures of the respective lobes of the cerebrum and cerebellum. The mass and form of the entire brain is the condition which determines the volume and curvature of the several compartments of the cavity which contains it, while the required mass of the entire organ is the condition which determines the permanence of the primordial form of antero-posterior curvatures.

l. The vomerine angle is the angle between the lower aspect of the sphenoid, and the posterior margin of the vomer. It is least in man, and increases as we descend the series of the mammals. The character of this angle is the primary con-

dition of the horizontal depression of the cribriform plate in man. It is the measure of the depression of the anterior extremity of the human cranial axis—*i.e.*, it renders it horizontal. It is intimately related to the vertical position and horizontal relations of the human nasal chambers, orbits, mouth, and lower jaw; as also to the depth and shortness of the facial portion of the human skull; and, finally, it is an important element in the examination of abnormal forms of skull, and in ethnological research.

The Brain.

a. The geometrical relations of the various parts of the skull in man and the animal, to which I have now briefly directed your attention, will, I trust, be sufficient to satisfy you that the subject demands a much more precise method of inquiry than has hitherto been employed; and, in addition, that it promises results similar in kind to those which we attained by the application of this method to the investigation of the trunk and limbs.

b. The additional space which is obtained in the human cranium, like the completed areas of the joints in the human limbs, is provided for additional structure and corresponding extension of functions. But where, as in the former, the additional structures and functions were at once recognisable; in the brain, on the other hand, we can, in the present phase of science, only recognise the masses added. Of the structure and function of those additional masses we know at present nothing, beyond the little which has been ascertained regarding the mechanism and actions of the organ generally.

c. The anatomy of the masses of the brain is the mere rudiment of the subject—the actual anatomy of the brain is its internal mechanism. Till that mechanism has been ascertained in man and the animal, the question as to the human and animal brain cannot be solved, and ought not therefore

to be discussed in a dogmatic tone. I shall be satisfied if I have succeeded in indicating to you the grounds upon which I myself entertain the firm conviction that, as the human brain exhibits in its geometrical proportions and mass a great superiority over the brain of any animal, a superiority similar to that presented by the human bones, joints, muscles, and organs of sense, so, in like manner, it may even now be safely assumed that under that cloud of ignorance which at present conceals its inner mechanism, there exists a structural and functional completeness which will be found to distinguish it from every other form of brain.

LECTURE VII.

TELEOLOGY AND MORPHOLOGY.

To complete the structural comparison of man and the animal, an examination of their respective arrangements for nutrition and reproduction should be now introduced. These two organic systems are more immediately related to the instinctive or animal department of the human economy, and the structures appertaining to them in man differ from those in the higher animal rather in their harmonious adjustments than in special modification.

The position of man in nature might then appropriately now occupy our attention, but as a preliminary to this aspect of the question we must examine the value of the differences between the structure of man and the animal, to which our attention has been directed in the previous lectures.

The values of structural differences and similarities vary according to the anatomical point of view. In this examination, therefore, we must keep the fundamental principles of anatomical comparison steadily before us.

The fundamental principles of anatomical comparison are involved in that twofold aspect which organic structure presents, and in virtue of which we are compelled to investigate every structural arrangement from two apparently opposite points of view; and thus to develope two parallel departments of the science—teleological and morphological anatomy.

Teleological anatomy investigates structure with reference

to its final cause; that is, in relation to the ends or purposes for which the structure and its parts have been provided.

Morphological anatomy, again, investigates the laws, the forms, and arrangements of structure, and entirely excludes the conception of purpose or function.

These two departments of anatomical science are not artificial divisions of the subject, but are essential in their respective characters, as resulting from the constitution of organic bodies themselves. Every form of animal body is a more or less composite system, the parts being constructed and co-ordinated to one another, and with immediate reference to its conscious principle, and to its area of action. Every part of its mechanism, therefore, is constructed not only in reference to other parts of the system, but also in reference to its entire economy.

You will now observe that the special anatomy of a single form, or the various special anatomies which collectively constitute the comparative form of the science, deals with structural differences rather than with structural similarities; for in the differences lie involved all those co-ordinations—structural, psychical, and cosmical—which collectively constitute a species.

As our instinctive belief—that every part of an organic structure or mechanism, like the mechanism itself, has an end or purpose in its constitution—is the principle which guides us in the prosecution and application of teleological anatomy; so, in like manner, we are compelled, in extending our examination of organic structure, to recognise the existence of laws of form and arrangement—*i.e.* formal laws in the constitution of organised bodies and their parts. We find, for instance, that the entire animal kingdom consists of forms, which fall into groups of greater or less extent, as characterised by the mere form and arrangement of the parts of their corporeal mechanisms. Now, from the constitution oı

the human mind, we are compelled to conceive for each of these groups an abstract conception, or type of mechanism according to which we find that, however varied the teleological anatomy of the constituent species of any group may be, all of these species, nevertheless, possess a mechanism referable to, and explicable by, the type of the group to which they belong.

In like manner, we find that the constituent organs and textures in a group constitute a formal series, in such a manner that, irrespective of their teleological differences, our scientific instinct compels us to express their relations in morphological laws, by which those relations may be inferred, and their character defined.

Organic morphology tends at present in four different directions :—

1. In the direction of questions bearing on the existence of a central type for each organic kingdom, or of one for both.

2. Towards group types.

3. To investigation of the types of organs.

4. To the investigation of the types of textures.

It is greatly to be desired that the teleological and morphological departments of anatomy should be kept distinct in their prosecution and application. The satisfactory advancement of both is entirely dependent on their respectively distinct methods of investigation ; and many obstacles have been opposed to the progress of the science of which they are the common elements, by incomplete conceptions of their respective objects and relations.

It is also much to be regretted that, in the present phase of our science, morphological anatomy threatens to overshadow the teleological aspect of the subject. Every question in general zoology and anthropology is now apt to be treated morphologically; so that there is a marked tendency to permit the purpose or final cause of organised structure to be overlooked.

If you keep steadily before you those principles on which every department of organic science must be conducted, and to which I have previously directed your attention—if you bear in mind that all the organic sciences lie in the boundary between the various departments of physical science on the one hand, and of moral and religious truth and belief on the other—if, moreover, you agree with me, that, when any question in organic science involves an element appertaining to the higher departments of truth and belief, its higher relations should be studied;—then, I say, you will see and avoid the danger which threatens the higher relations of anatomico-physiological knowledge in the present phase of the science. I need scarcely remind you that I have strictly adhered to these principles in my previous lectures. I have not treated the anatomical questions which have come before us on morphological, but on teleological grounds. I deemed it quite unnecessary to inform you that the human body is constructed on the mammalian type, and that therefore its characteristic features would be found to consist merely in modifications of mammalian structure.

No one would be inclined to deny that the general aspects of the human body, and the body of a higher ape, resemble one another more than do the aspects of the frames of the highest and the lowest ape. But I have, I trust, satisfied you that the human body presents a whole series of perfected arrangements of structure, bearing immediately on the higher conscious or rational principle of man—arrangements which are deficient in all apes alike, and which thus collectively, by their absence, distinguish all the apes from man corporeally as precisely as their instinctive form of consciousness separates them from man psychically.

LECTURE VIII.

THE POSITION OF MAN IN THE SCALE OF BEING.

1. In my previous lectures I have brought successively under your consideration—

1st, The instinctive character of the animal;

2d, The combined instinctive and rational constitution of man;

3d, The characteristic completeness of human structure;

4th, The danger of overlooking the teleological aspect of structure in our zoological and anthropological investigations.

I now proceed in the present lecture to lay before you the conclusions to which, in my opinion, we are led by this comprehensive mode of viewing our subject, and so as to indicate to you the nature of those relations on which the fundamental dignity of the human body depends.

2. I must, however, before proceeding with the subject of the present lecture, bring more fully under your consideration the principle stated in my last lecture—that all organic science, but more especially its anthropological department, inosculates with the higher forms of truth and belief so intimately and extensively as to render the discussion of the higher questions as to organisation absolutely futile, if dissociated from their co-ordinate department of psychological, moral, and religious truth and belief.

3. You will acquire a clearer conception and a firmer grasp of this important principle, if you bear steadily in mind—

1st, That all those departments of organic science which

deal with the material elements of organisation can only be investigated, and successfully prosecuted, by the faculties and methods appropriate for our human acquisition of the science of matter.

2d, That the psychological departments of organic science can, in like manner, only be investigated, and successfully prosecuted, by the faculties and methods appropriate for the science of mind.

3d, That the moral and religious elements in the human constitution not only indicate, by their very nature, a method of inquiry and a kind of evidence distinct from those on which we base our knowledge of matter and of mind, but also involve, as their absolute character, that immediate relation which they have to the "intelligent and powerful Being who," in the words of Newton, "governs all things—not as the soul of the world, but as the Lord of the universe; who is not only God, but Lord and Governor."

4. It is also essential, for the legitimate study of the higher anthropological questions, that you should have satisfied yourselves as to the stability of the grounds of your belief in each of the three departments of truth to which I have referred. The material and sensual phase of our human economy tends to foster rather than to repel a reliance on the truths of pure science, and thus gives a preponderance to the study of the structural department of anthropology.

The apparent inapplicability, again, of mental science, and the consequent prejudice against its study, as well as the somewhat painful process of self-conscious thought (if I may be permitted to make use of the expression) which its study demands, have all conduced to withdraw the attention of anthropologists from the psychological department of the subject.

And again, the evidence afforded by the revealed record regarding the origin, constitution, and position of man, is apt

to be undervalued or denied in the general discussion of the subject. The tendency of anthropologists to undervalue this source of evidence depends, in the first place, on the illegitimate application of a legitimate principle, that a question in science should be decided by science alone. In the second place, the tendency arises from that reserve in regard to our higher beliefs, which is the result of the varied and conflicting forms which religious belief and thought present in the present personal, social, political, and ecclesiastical phase of humanity. In the third place, the tendency to dissociate the evidence of sacred history from anthropological research, is due to that deep-rooted and prevalent prejudice, which, dissociating the revealed record from the book of nature, leads to the assumption that those higher truths and beliefs, which are involved in our human constitution, and the purposes and results of which are recorded in the book of God's word, for the direct information and enlightenment of our higher faculties, towards our final development, should be considered a department of knowledge and belief quite apart from the truths contained in the book of nature; for the attainment of which truths, and in corroboration of revealed truth, our intellectual faculties were bestowed upon us.

5. I may here observe, that although I have deemed it necessary, for the full exposition of the subject of this course of lectures, to put prominently forward an aspect of our subject, which may be termed non-scientific by those who differ from us, I am not thereby called upon to establish the legitimacy of that aspect. For, in my opinion, those who consider it untenable are bound to take one of two courses—either to refrain from viewing a non-scientific subject through a scientific medium, and to have recourse to the method of inquiry proper to a non-scientific department of human knowledge, or to act upon that sound principle in philosophy and science which withholds those who may not have made them-

selves acquainted with all the elements of a given question, from taking any part in the discussion of that question.

6. I have already, in my first lecture, submitted to your consideration the grounds on which the instinctive conscious principle must be held as the fundamental element of the animal. This immaterial principle, in virtue of its created constitution, is the agency which determines the actions and regulates the processes of its corporeal frame ; not only the form and construction of the animal body, but also the actions which it exhibits in support of its own frame, and the furtherance of its purpose in the economy of the world, are strictly considered by its immaterial element. We are compelled to admit, by a process or argument of elimination, that even in the highest animal, its perceptions—its emotional, intellectual, and determining faculties are predetermined for it in the conditions of its economy.

To the immaterial principle, which we are thus compelled by an indirect method of research to admit as the essential element of an animal, various terms have been applied.

The ψυχή we hold to be the soul of the animal, irrespective of all questions regarding its nature. It must be *that* in which the instinctive consciousness of the animal subsists. It must be *that*, lacking which the organisation of the animal could not exist. The organic world differs from the inorganic, in that it consists of individual organisms, each of which exists essentially in virtue of its indwelling *Psyche.* It is not for a moment to be assumed that the *Psyche* of an animal is the immediate agent in the processes of organisation, or that the forces of matter are replaced in the living structure by forces of another kind. The forces which act in organisation are natural forces, however peculiar the form and arrangements of their results may be. We are not entitled to assume more than this, that in organisation the material forces are determined, as regards their mode of action, by the indwelling

power of the *Psyche.* A force is not a power in itself, it is merely an expression for a law of action in matter.

The intimate nature of force is entirely hidden from human contemplation. Again, in like manner, as we recognise *force* in the phenomena of matter by our senses through the intellect, we recognise *power* in the fulfilment of the effort of the will on our muscles, etc., by our self-consciousness, and we may legitimately, on the principle already stated, attribute it also to the animal. *Power,* therefore, differs from force in that the latter is attributable to matter only. An immaterial power has been given to the animal so as to put it in possession of such efficacy, or deputed *power* as may be necessary for those peculiar manifestations of the constructional material forces of its organised body, and the manifestation of those instinctive actions for the fulfilment of which the organism has been provided.

7. All trustworthy investigators of this subject have come to the conclusion that man in his constitution consists of three elements—a corporeal, a psychical, and a spiritual; and the direct, as well as the indirect evidence supplied by the revealed record, fully confirms this conclusion.

8. The *Psyche* in man must be assumed as the instinctive element of his threefold constitution. Upon its deputed efficacy depends that determinate and co-ordinate action of all those physico-chemical forces which are collectively engaged in the development of his body from the ovum, and in his life-long structural modifications and physiological actions. In the form of the human *Psyche* also are developed all those fully completed structural arrangements in the human body, to the nature and character of which I have already directed your attention. In the *Psyche* of man also are *based* all those instincts, emotions, appetites, and passions, which, stronger, keener, and more numerous than in the animal, were conferred on man for his higher purpose and greater enjoyment, so long as subject to his higher principle; but which have,

under his freedom of choice, become the sources of misery and death. In the revealed record the term σὰρξ, *Flesh*, is applied to what I may be permitted to designate as a distinctive physiological feature in the human economy, that combination of the *Psyche* and corporeal mechanism which constitutes in man his organism properly so called. The human organism is the animal in man. In it alone does he resemble the animal. Yet, nevertheless, he stands alone among the organised beings of this globe, in his disobedience to the laws of that organism, with the power over which he has been entrusted, in virtue of his spiritual principle, for his own benefit and enjoyment, and for the final purposes of his creation.

9. The human body, developed under the influence of the more extended efficacy of its indwelling *Psyche*, is fitted thereby to serve as the instrument of that spiritual element in the human constitution, in which consists the personality of man.

10. I have in a previous lecture brought under your consideration those features in the spiritual element of man, in which it differs from the Psyche of the animal and the Psyche in man himself. We found that in this element consists the essence of his rational consciousness, in virtue of which he is *self-conscious*, capable of thought properly so called; of language, which is merely the phonetic expression of thought; and of all those conceptions, intentions, and co-ordinated emotions, which, manifested in language oral and written, or incorporated through the instrumentality of his material frame, constitute those various forms of science and of art—those multiform arrangements of social, political, and religious import, which distinguish man from every form of animal.

11. Man, in virtue of his possession of a spiritual principle, by which alone he is capable of thought and speech, and is impressed with the belief of moral truth and divine agency, stands alone among the organised beings of this globe.

I assume, also, that you are now prepared to admit that the existence of a spiritual element in the constitution of any being associates that being with the spiritual world, even although, in furtherance of his own future welfare, and in conformity with the arrangements of providence, we find him provided, at the same time, with an organism adapted as the present instrumental means of his spiritual agency.

I believe, moreover, that you will freely admit that an organism adapted for a spiritual end must necessarily be of a higher character, and more complete in its construction, than any organism provided for a merely instinctive being.

12. As the respective subjects of my present, as well as of my two succeeding lectures, demand for their satisfactory consideration a clear conception and steady grasp of the results of our previous inquiries, I shall, before proceeding, put these results in a categorical form.

a. The psychic principle in man and in the animal, although immaterial in its nature, and therefore recognisable only by its manifestations through the consciousness, is distinguished from the spiritual principle in man by the immutability of its powers and attributes, and the strict co-ordination of these to its proper sphere for each species of organism.

b. On the other hand, the *Pneuma* or spiritual element in man, also immaterial in its nature because only recognisable by its manifestations through the consciousness, although in its endowments strictly co-ordinate with the purpose of man on earth, and with his future eternal destination, is nevertheless subject to his will, so that, in the present state of man, the powers and attributes of his spiritual or proper element are applicable or not, for his present and future welfare, as may be determined by that freedom of choice involved in the nature of his human will.

c. We have already seen that, not only is the individual economy of an animal fully and strictly provided for in its

psychical element, but we have also seen that, by the same agency, the purpose of the animal in creation is secured.

d. We have also seen that man's capability of existing over the entire globe, and the peculiar and extended agency which he exerts in modifying and perfecting certain of its arrangements, and taking advantage of others for his own welfare, are due, not to the agency of his psychical or instinctive element alone, but essentially to his rational consciousness, which again is merely the manifestation of his spiritual principle.

e. But we have, moreover, seen that the animal invariably acts up to the laws of its specific constitution; whereas man has a free choice in his actions. The extent, therefore, to which the agency of man is exerted towards the welfare of his own economy, the prosecution of his proper function on this globe, and for his education for a future life, is dependent on the use which he makes of his faculties in the discrimination of truth and error, right and wrong, and on the application of this discriminating power to the control of his actions. All errors, therefore, committed in the exercise of this discriminating faculty, and all actions induced by such errors, and, *à fortiori*, all actions performed contrary to a correct determination, are necessarily contrary to the constitution of the human economy; and must, therefore, be essentially detrimental to it.

13. From what has now been stated, it follows that the welfare of the entire human constitution, of the organic, as well as of the spiritual economy of man, is conditioned by the proper action of the spiritual element itself; and, consequently, that we are to look to this higher principle in his constitution for an explanation of all those circumstances which have cooperated in producing the numerous modifications of his typical form, and in the recurrence of the many vicissitudes of his history, which are so distinctive of his race.

14. In considering the human constitution from the point

of view we have now attained, we cannot divest ourselves of the conviction that our spiritual principle, which enables us, in virtue of our forms of thought, to ascertain the laws of God in the works of creation, and which also, in virtue of our moral intuitions, indicates to us those personal and relative duties, by the performance of which we can alone retain our similitude to the Divine nature, could have been bestowed upon us for any other ends than our own welfare and the fulfilment of a Divine purpose.

We have now reached a point from which we may legitimately examine the question as to the position of man in the scale of being.

The previous part of the course has been devoted to the elucidation of the following principles:—

1*st*, That the specific character, as well as structure, general economy, and final purpose of an animal are fundamentally conditioned in its instinctive, conscious, or psychic principle; or, in other words, an animal is an organism.

2*d*, That the distinctive character of man consists in the subordination of his organism to his human spiritual principle.

3*d*, That man owes to his spiritual principle that self-conscious intelligence on which depends his sense of responsibility; and

4*th*, That the animal kingdom consists of a series of mere individuals; humanity, again, of a community of persons.

If you keep these principles fully in view, you will perceive that those duties to be fulfilled, which collectively constitute the personality of a man, are totally different in kind from the instinctive actions of an animal individual. But as the duties fulfilled by a man are as essential to his welfare in his extended sphere as the instinctive actions of an animal are to its welfare in its limited area, so the recognition of his spiritual principle, in which consists the intellectual and

moral economy of man, is no less essential for the discrimination of his position in the scale of being, as the recognition of the instinctive economy of an animal is for the determination of its zoological position.

Now, if it be a sound zoological doctrine that all the conditions of life in an animal ought to be taken into account in ascertaining its position in the zoological scale, so in like manner ought the spiritual economy of man to be taken into the consideration of the question as to his relative place in the animal series. To my apprehension, his possession of a spiritual principle entirely excludes him from the scale of mere animal being, even although he possesses an animal organism. I shall endeavour, in my next lecture on Retrogressive Man, and in my succeeding or concluding lecture on Progressive Man, to elucidate more at length the supremacy of the spiritual principle in the economy of man. But, in the meantime, to bring the present lecture to a close, I must now ask you to consider whether that completeness of the human body, to which I have directed your attention in my 3d, 4th, 5th, 6th, and 7th lectures, does not also entirely exclude man from any legitimate place in the animal kingdom.

LECTURE IX.

RETROGRESSIVE MAN.

1. The human race is characterised by the great varieties which exist between different peoples. The question is not unfrequently asked, Was not man originally savage? Was he at one time near the brutes? I believe that man was not originally savage, and that the less civilised races are not undeveloped, but degraded forms.

2. Man, in virtue of possessing a spiritual element, stands alone amongst the organised beings of the globe. The existence of this element associates the being possessing it with the spiritual world. An organism adapted to a spiritual end and capable of acting in space in the most perfect manner, must be more highly developed than one not so adapted. Man's body is formed on a rectangular system—that is, he can extend his limbs so as to place them at right angles to each other.

3. The results of our inquiry are—1*st*, the psychical principle in man and animals, although immaterial, is distinguished from the spiritual in man by the immutability of its powers and attributes, and is especially adapted to each species. The pneuma, or spiritual element in man, also immaterial, and only recognisable by its manifestations through consciousness, is strictly co-ordinate with man's sphere of action on earth and his future destination. It is, nevertheless, subject to his will. Not only is the individual economy of the animal strictly provided for, but by the same agency the purpose of the animal in creation is secured.

4. Man's capabilities of existing over the entire globe, and

the peculiar extended agency which he exerts, are due not only to the agency of his psychical instinct, but to his rational consciousness, which is provided for by his spiritual element. The amount of good he does depends upon the use he makes of his faculties. The welfare of the entire human constitution, organic as well as spiritual, can only be conditioned by a proper action of the spiritual element. This has always to be remembered in looking for an explanation of all the varieties of race and of individual personal character. Why, then, should man alone, of all the living beings on this globe, have been left so unfettered that his welfare should depend on his own choice?

5. Herein lies the great mystery of humanity, on the existence of which depends that *religiosity* which is characteristic of every form of the human race. The consciousness of untruth, and of error in some form or other, exists in every modification of man; and it is equally certain that all the vicissitudes of human history, and all the distress against which man has had to struggle, have been directly due to his tendency to untruth, and his liability to error.

6. I need scarcely remind you that these statements are not merely scientific in their character. The grounds on which I believe them are not scientific grounds alone. The evidence on which you have satisfied yourselves regarding them is involved in moral science, and in those statements of that revealed record by which our higher beliefs are enlightened, confirmed, and sustained. The statements which I have submitted to you, regarding the dependence of our human economy on the wellbeing of its spiritual element, are unanswerable; and therefore, on the grounds already submitted to you, the principle itself must necessarily be employed by the anthropologist in the discussion of any of the higher questions of his subject.

7. I would lay it down as a principle, that whereas we

are not to look to the revealed record for scientific forms of statement, we are, nevertheless, from its character, entitled to assume, that wherever statements are made in it, bearing on the intellectual, moral, and religious departments of the economy of man, in their relations to his material economy and conditions of present and future existence, the sense or bearing of these statements will not only not be contradictory to, but, on the contrary, confirmatory of, the scientific results of human research.

8. We are informed in the revealed record that in the primitive phase of his existence the economy of man presented a more perfect form, and that he existed under conditions commensurate with the complete fulfilment of his welfare. We are also informed, in terms which, whatever their immediate import may be, at least involve the statement, that man lost his primitive form of economy, and his more favourable conditions of welfare, by the erroneous use of his higher or spiritual principle, by his preference of untruth to truth, of error to rectitude; and that thereupon humanity became subject to all those ills which have chequered its progress.

9. The statement which I have now made involves a truth which belongs to the departments of the moralist and theologian. But it is one which cannot well be neglected by any thoughtful mind; and from our point of view, looking at it as anthropologists, it is full of interest, as it is in fact a fundamental principle in the science of the human economy.

10. As the time allotted to this course of lectures is too brief to admit of detailed illustration, and as the inculcation of sound and comprehensive principles is of primary importance in such subjects as this course has been devoted to, I shall, in concluding this lecture, merely indicate the tendency of my previous statements.

11. On the grounds already stated, we are bound to guard ourselves against the conscious or unconscious assumption,

that the development of humanity can be legitimately or safely investigated as an anthropological subject, without reference to the primitive condition of man as presented to us in the revealed record.

12. As we deduce all the personal and social misery of man on this globe from his erroneous choice of action through neglect of his higher principle of belief, so in like manner we are bound to attribute to the same source the causes which have produced all the so-called forms of savagism and imperfect civilisation, as well as the so-called imperfect forms of human structure as presented to us in our ethnological or archæological inquiries.

13. Finally, I hold that liability of man to disease is intimately related to the neglect of the dictates of his higher principle.*

* The reader will find a fuller statement of the author's views on this matter in the "Address to the Graduates" and in that to the Medico-Chirurgical Society.—Eds.

LECTURE X.

PROGRESSIVE MAN.

1. In my last lecture, after showing you that the discussion of any fundamental question in anthropology must necessarily be based on three convergent lines of evidence—the physiological, psychological, and theological—I proceeded to the consideration of the question of primitive man. From the comprehensive character of the evidence afforded us, I laid before you what appeared to me sufficient grounds for believing primitive man to have been, not a savage, but man in his originally perfect form, fitted by the undegraded character of his spiritual element for immediate converse with his Creator, in whose image his spirit had been framed, and by whose instruction he was initiated in regard to his moral and spiritual nature; guided to the use of his faculty of speech, and to the application of his intellectual powers, in the investigation and appropriation for his own welfare of the objects and living beings by which he was surrounded.*

I also submitted for your consideration the grounds on which we must, in my opinion, hold that the phase of humanity in which we ourselves live is a secondary phase, in which man has lost the completeness of his primitive economy, and his more favourable primitive conditions of

* It may not be out of place to refer to the recently published work *On the Antiquity of Intellectual Man*, by Prof. C. Piazzi Smyth, in which a conclusion similar to that expressed in the text has been arrived at from the consideration of a different line of evidence to that employed in these lectures.—Eds.

existence, as evinced in the degraded and helpless condition into which the greater part of humanity in all ages, as well as in the present, has fallen, and not less so, in the unsatisfactory aspect which our modern so-called civilisation presents ; and that, therefore, had humanity in its present phase been dependent on its own resources, as the animal is, no section of it could have resisted the retrogressive tendency, or have opposed the obstacles to that progression on which the hopes of man are fixed.

2. In the further prosecution of our subject, I would now observe that while we are compelled, on the grounds already stated, to view all the less perfect forms of humanity as retrograde forms of earlier or later date, produced by independent but similar moral influences, we are at the same time brought to see in the present phase of humanity a progressive series of advancing forms of society, a series continually increased by collateral additions, but extending backwards uninterruptedly to the commencement of the phase. The twofold retrogressive and progressive character presented by the history of man is from every point of view peculiar, and completely distinguishes his economy from that of any animal, and at the same time constitutes as important a feature in his physiological as in his political and moral aspects.

3. As I have already told you, we are not called on here to define, if that were possible, the entire economy in the primitive condition of man ; nor to inquire into the specific nature of that change which took place in his economy on his entrance into his present phase of existence. It is sufficient for our present purpose that we are assured of the fact that the change in the economy and welfare of man was the result of an act which involved a breach of his moral principle. Now, we have already examined the grounds on which we must hold, that as the psychical is the primary and controlling element which secures the welfare of the animal, and fulfils its purpose in nature, so, on the other hand, the spirit

in man is that element in his economy on which his entire welfare depends.

Now, as the moral department of the spirit involves the higher relations of our being, and assuming that you are acquainted with the grounds on which our moral, and in fact spiritual economy, involves responsibility, and the consequences of such responsibility, it will be evident to you that a breach in the moral department of our spiritual element must affect the integrity of the entire human economy.

4. By the term "entire human economy," I mean the entire economy of man, as manifested in his physiological, intellectual, and moral capabilities ; and I am anxious that you should distinctly see how it is that the integrity of our corporeal or physiological frame, the applicability of our intellectual powers, and the free action of our moral faculties, do all depend on the condition of the spiritual element of our being.

5. We have now reached a point from which we can look back to the subjects of my first and second lectures. In the first lecture I explained to you how the welfare and purpose of the animal are provided for in its merely instinctive form of consciousness, in virtue of its psychical element. In my second lecture I explained how the welfare and purpose of man on earth are provided for in his rational consciousness, in virtue of what you will now recognise as his spiritual element.

We may now consider, therefore, the nature of animality as consisting in a physiological structure, conditioned by an immaterial element of a merely psychical character—*i.e.* as before explained, an animal is a mere organism.

The essence of humanity again consists in the human organism—*i.e.* the combined physiological and psychical element, co-ordinate with, and subject to, the control of a spiritual element. The essence of humanity in fact consists in a spiritual element of which the co-ordinate organism is the in-

strument. Thus, I hold with those anthropologists who do not place man in the animal kingdom, so that he is not to be regarded as an ordinary subject for zoological inquiry. The relation of man to the animal which is next to or immediately below him cannot be determined. Man is a perfect being in his structure, and is excluded from all animal forms by his completeness. We cannot conceive an animal preserving the vertebrate type developed beyond him. If man were, as some suppose, at the head of the animal kingdom, some ape should be found to stand immediately beneath him ; but the apes are all related to each other, and grouped around a type which is that of an ape.

6. As I have already, in my last lecture, directed your attention to the two aspects presented by humanity in its present phase, and characterised these aspects as Retrogressive and Progressive, it is in my opinion very important that you should satisfy yourselves as to the stability of the principle that these two aspects are essentially dependent on moral causes. The entire question, as I have already told you, is, like other fundamental questions in anthropology, a composite question—its most important factors being theological and moral, and such as I, in my position here, have merely to allude to. But it may be well, at this point of our inquiry, to illustrate the influence of moral error from a physiological point of view.

7. Let us take the case of the animal. If the various instinctive acts, by the performance of which the animal provides for its individual wants, and fulfils its various functions in relation to its own kind, and to its end as a species, be considered, they arrange themselves into three groups, viz.—

1*st*, Its actions in relation to itself ; 2*d*, its actions in relation to its fellows of its own species ; and 3*d*, its actions in relation to its performance of those purposes for which it was created, and placed in its given area.

These groups correspond respectively to the actions of a man—

1*st,* In relation to himself; 2*d,* in relation to his neighbour; 3*d,* in relation to his Creator. But as the entire corporeal integrity of an animal, and the applicability of its instinctive capacities are dependent on the invariability of its instinctive actions, the welfare of the economy of an animal is never modified beyond its determined limits by any error in its actions towards itself, its fellows, or its Creator. Its economy is continuous; it cannot of itself induce either a retrogressive or a progressive form of its economy.

From what we have already seen, it is evident that if we may be permitted to assume the addition of a spiritual, that is of a responsible, element, to the constitution of an animal—then its three groups of relative actions would be elevated to the rank of duties to be performed, which again would involve the correlative errors to be avoided, and the consequences of such errors.

8. The neglect by man of the three groups of duties which collectively conduce to the end or purpose of his creation, is undoubtedly the source of those deteriorated forms of his economy which together constitute his retrogressive aspect. You will, of course, clearly understand that the statement I have now made not only does not exclude but fully admits the influence of all the cosmical and physical elements or conditions of ethnological, national, political, and social differences in humanity. But as man was placed on this earth to fill and to subdue it, it is evident that, in so far as he has permitted such cosmical or material influences to detract from his spiritual efficiency, he himself is to blame, and that it is now his duty, in his present phase, to develope his progressive form, under the conditions provided for that purpose.

9. I need not remind you that the conditions provided

for man, to enable him in his present phase to counteract the deteriorating tendency of his spirit-element, and so to work out his proper end, are those conditions which, announced to him at the commencement of his present phase, have assumed, under Providence, that form of belief, and that kind of motive to action, which we term Christianity.

10. It would be out of place to enter here into detail as to the influence which Christianity has exerted on man. I would only impress upon you, as students of science, that science, properly so called, had its origin within the Christian era; that its progress is one of the results of Christianity; and, moreover, that one of the greatest dangers to which the Christian system is at present exposed, is the erroneous tendency to elevate science above the other forms of human belief.

11. Gentlemen, I thought it necessary to touch upon this subject—I trust in a manner due to its nature—for the purpose of enabling you to comprehend more clearly the statement which I made in a former part of the course, that the human body derives its completeness and its entire character from its adaptation to its special purpose, as an instrumentality under the guidance of the human soul towards the end for which man was placed on this globe.

II.—ON LIFE AND ORGANISATION.*

THE gradual augmentation † of acquired knowledge is the result of many series of contributions, originally independent,‡ which, converging as they advance, and coalescing more or less intimately with one another, finally assume their permitted positions§ in the mass of human knowledge.

Every subject of investigation, however isolated it may once have been, absorbs in its progress,‖ and then assimilates, minor collateral inquiries; and is itself destined to resign its original independence. Certain sciences coalesce easily, and their union is hailed by their cultivators as a triumph of the common cause. Other sciences coalesce with difficulty, and their anticipated union is distasteful to their respective investigators. This difference primarily depends on the necessary existence of fundamentally distinct modes of inquiry in each department of investigation. It depends secondarily on the greater or less difficulty of the final step necessary to effect the union; and on the comparatively few inquirers who possess either the original or the acquired power of adopting two or more fundamentally distinct modes of investigation in the prosecution of an essentially complex subject. Only such a mind as that of Faraday, which admits of the simultaneous conceptions of the chemist and the physicist, could have guided into one channel the different departments of his varied subject; and the remarkable results of recent physio-

* This Lecture was delivered by request to the members of the Royal Medical Society, in their Hall, in 1856, and has not previously been published.—EDS.

† Note I. page 299. ‡ Note II. page 300. § Note III. page 300.

‖ Note IV. page 302.

logical research in Germany could only have been induced by the influence of an intellect like that of Johannes Müller, which is equally at home in the domains of the natural, physical, and psychological sciences.

There are, therefore, certain subjects of inquiry which at certain epochs in their progress are obstructed by peculiar difficulties. Such an epoch occurs when one subject is about to merge into another, or when a particular subject, complex in its nature, has reached that stage in its progress at which it must henceforward demand for its investigation, two or more fundamentally distinct modes of inquiry. At any epoch of this kind, in the progress of any science, an attempt should be made to determine its present position, to define its real obstacles, and to ascertain whether the previous mode of inquiry had involved all the fundamentally necessary methods of research.

The science of organisation has reached an epoch of this kind. It has become absolutely necessary for every one engaged in the study or investigation of the science to make himself acquainted with its present circumstances, and to ascertain the probable direction of its future course.

I propose, in this lecture, to give a brief summary of my own views on this subject, and I would here express the gratification which I feel in having an opportunity afforded me of stating these views to the members and visitors of a society which has for a long period been largely instrumental in the development and propagation of organic science.

Three distinct groups of subjects engage at present the attention of physiologists :—

1. The structure and actions of the living organism considered as a chemico-physical system.
2. The numerous forms in the series of organisms, embryo and adult, viewed as modifications of certain abstract organic forms or ideal types.

3. The connections between the corporeal and psychical elements of organisation.

The structure and actions of the living organism, considered as a chemico-physical system, have at all times furnished the principal subjects of anatomico-physiological research. The structure or anatomy of this system, and the actions or functions of its constituent parts, form, in fact, the mass of physiology as usually understood.* The progress of this perfectly natural and absolutely necessary line of inquiry has been more or less retarded at different periods by the tendency of physiologists to complicate and divert the investigation, by assuming the immediate agency of a presumed principle of vitality. Overlooking the philosophical conditions of the question—that there are at least two series of facts to be determined in the living organism, differing fundamentally in kind, and therefore requiring fundamentally distinct methods of research,† physiologists have been too apt to consider their science as throughout independent of others, and they have, consequently, opposed serious obstacles to its inosculation, in certain of its departments, with the physico-mathematical sciences on the one hand, and with the psychological ‡ on the other. We have now, however, reached an epoch from which we may proceed to investigate the chemico-physical properties of the living organism, with less risk of being misled by false theories of vitality, and without dread of collision with the philosopher or theologian. The chemico-physical properties of the living organism, strictly investigated by the legitimate methods of chemical and physical research, have yielded the principal triumphs of recent physiology. And there is now, at least, an assurance that in addition to the precise processes of modern chemistry, the physiologist

* Note V. page 303. † Note VI. page 303.
‡ Note VII. page 307.

must henceforward be prepared to employ in his researches the mathematico-experimental methods of physical science.

The advance which has recently been made in ascertaining the structure and actions of the living organism considered as a chemico-physical system, consists—1*st*, of the recognition of the depth and extent of chemical action in the economy; 2*d*, of the evidence latterly afforded of the primary importance of the electrical force in the organism generally, but more especially in the actions hitherto considered more essentially vital; 3*d*, of the detection of the connection between the chemical and electrical actions of the organism, and its recently discovered microscopic structure; 4*th*, of the successful efforts made to determine by physico-mathematical methods the precise forms and reciprocal mechanical actions of the different parts of the organism.

The second group of subjects which at present engages the attention of physiologists, is the investigation of the numerous forms of organisms, embryo and adult, viewed as modifications of certain abstract organic forms, or ideal types. These subjects constitute morphology, properly so called. Although an essential element of physiological science, morphology is only of recent growth. Its development was retarded for many years by the influence which results from the fundamentally peculiar nature of the subject. It is peculiar in this respect, that it does not contemplate at all the actions or uses of parts, but only their presence, their forms, and their relations in any one species of organism as compared with other organisms, and with a view to the determination of the general plan, according to which they have all, each after its kind, been constructed. The influence which has retarded the progress of morphology, as it has retarded other departments of science and philosophy, is that difficulty which the generality of minds experience in conceiving the possibility of any phenomenon or action having a double relation—of its being conditioned,

not only by the necessities of the individual system of which it is a part, but also by the unity of the entire scheme of the universe.

The third group of subjects which at present engages the attention of physiologists, is the connection between the corporeal and psychical elements of organisation. The views of these subjects taken by different physiologists differ according to the philosophical principles which they have severally adopted under the influence of individual intellectual tendency, or of education. Three tendencies characterise present opinions on these subjects. These tendencies may be distinguished as materialistic, idealistic, and spiritualistic.

That mind is a product, or a function, of the matter of the organism, is a dogma which cannot be considered as at present on the decline. Within the last two years it has been re-asserted and supported with extraordinary dogmatism. "As contraction is the function of the muscle, as the kidney secretes urine, and the liver bile, in like manner the brain produces thoughts, determinations, and feelings." These are the words of Carl Vogt, and they express the opinions of a considerable section of the most accomplished naturalists, physiologists, and physicians in Germany.

The idealistic opinions on these subjects, based on the assumption of the identity of matter and mind, are now on the decline in that country where the philosophy on which they are based took most extensive root. In Britain this system of philosophy, although nowhere more ably advocated, has never even partially influenced physiology.

It is remarkable that the recent advance of Physiological Chemistry and Physics, while it has produced increased confidence in the materialistic doctrine, has nevertheless afforded for the first time a physiological confirmation of the essentially spiritual nature of mind. The high probability that the complex structure of the brain consists only of

peculiarly arranged groups of nerve-cells, connected by nerve-fibres, and that its actions consist merely of polar forces acting as physical currents along the nerve-fibres, and induced by external agencies, or by the nerve-cells of the organ itself, while it may confirm the expectations of the materialist, and has apparently excluded the mind from any appropriate locality—has, in fact, placed its essentially peculiar character on its proper basis.

It is important to observe that the three groups of subjects into which Anatomy and Physiology have latterly become developed are in themselves essentially distinct, and demand for their investigation fundamentally distinct methods of inquiry. The chemico-physical group requires for its development the experimental and mathematical methods of the chemist and natural philosopher. The morphological group can only be investigated by an intellect naturally fitted for, and trained in, the peculiar essentially formal method of the natural sciences. The third group demands the exercise of the human self-consciousness on itself, and the application of the results to the elucidation of psychical manifestations generally; it demands, in fact, the altogether peculiar method of philosophy proper, and of inductive psychology.

It is, moreover, important to observe that these three departments afford no immediate promise of coalescing. They have come into contact, and are advancing parallel to one another, but there is apparently no immediate relation between the laws which respectively regulate them. The nature of the connection between the chemico-physical properties of the living organism and its psychical manifestations will, in all probability, continue a mystery. But with equal confidence it may be asserted that the crowning triumph of physiology will be the reduction of the teleological and morphological principles of structure to one central law.

Having now endeavoured to ascertain the present position

of the science of organisation, I propose, before proceeding farther, to consider briefly the more remarkable characteristics of the living organism.

Every living organism is a distinct system, the constituent parts and powers of which are not only reciprocally adapted to one another, and to the whole, so as to subserve the internal economy of the system; but are also so adapted as to enable the entire organism to fulfil the external conditions of its existence. The living organism, although a distinct system, is not an isolated one. It is a part of the Cosmos, and as such has three sets of relations—its own internal or structural relations, its relations to other living organisms, and its relations to those localities within which the primary conditions of its existence have been determined. These three sets of relations are provided for mainly by the corporeal structure and actions of the organism; but the first and third are, to a certain extent, and the second is chiefly, fulfilled by the psychical powers. These three sets of relations are, moreover, so connected with the structure and constitution of the organism, that we cannot, in our investigations into the nature of life and organisation, omit the consideration of any one of them. It is a fundamental canon in philosophy, that all the conditions of any question must be taken into consideration. So, in this complex question as to the nature of the living organism, we are bound not to overlook one set of its relations while engaged in the investigation of the others. While tracing the relations of the bodily structure to the internal economy, and to the external conditions of existence of the organism, we must not overlook the corresponding psychical powers with which it is provided; nor, while inquiring into its psychical manifestations, can we omit the consideration of its somatic peculiarities.

Here I would also observe, that in attempting to solve the question as to the nature of organisation, physiologists

have not only been too apt to overlook the various relations to which I have already alluded, but also to keep out of view certain peculiar chemico-physical characters presented by it. They have been too much inclined to view its parts merely as portions of a machine teleologically adapted to one another; and to neglect those structural features and distinctive actions in which it differs from any ordinary mechanism.

Organisation is never met with except as part of an organism—that is, of an individual material living system.

The organism is born, or commences its life, as the product of one or of two parents of like kind with itself.

The living organism invariably dies.

The duration of the life of every organism is specific, varying only within certain restricted limits—the causes of the variation being contingent circumstances in the conditions of its existence.

The matter of the organised frame, to its minutest parts, is in continual flux; so that what is permanent in the organism is not the matter of which it is composed, but, as far as the ordinary exercise of our senses enables us to determine, its form only.

The chemical constitution of each group of the ultimate organised parts of the frame is specific. In like manner, the chemical constitution of each part of our ultimate organised part is different.

The ultimate chemical elements of the organism are merely certain of the ultimate chemical elements of inorganic matter. But the secondary, or organic chemical principles, although some of them have already been produced artificially, and although all of them will probably be ultimately formed by the chemist, are never met with in nature except as the materials of, or in connection with, organisation.

The forms of living bodies, and of their parts, even of

their minutest structures, are peculiar. They seldom, probably never, present straight margins, flat surfaces, or angles. They are very generally spheroidal, but never absolutely spherical. Ellipsoidal and paraboloidal surfaces are met with, and still more complex forms occur in connection with that essentially organic curve, the spiral. Curves of double curvature, surfaces with complex geometrical relations, constitute the predominating forms in organisation.

As the matter of the living organism is in continual flux, so we find that the fresh matter which is constantly added to it becomes united to it, not at its outer surface, or at the outer surface of any of its minutest organised parts, but in its interior; at every part of which, again, the fresh matter is united to the ultimate organised particles, not at their exterior, but by passing into their interior, to be distributed therein for final union.

Connected with this latter peculiarity is the remarkable series of phenomena presented during the development of the organism, while still in connection with, or after detachment from, its parent. Science recognises no process of development except that of the individual organism from pre-existing parents of the same unalterable species. The development of the organism resembles no other series of material changes in any system in nature. Even the minutest part of an organism, however complicated it may be, is evolved or unrolled from within outwards. Cell after cell, fibre after fibre, organ after organ, each in its own peculiar but strictly organic manner, appears at the centre of its own organic district. They make their appearance at set times, at stated periods, and in ever-increasing numbers, to the close. Passing off from their original centres, they assume their proper places in the composition of the complex machine-cell, commencing originally in the interior, but frequently protruding during the process, parts of slow become enveloped by others of more

rapid growth, to be again exposed, at a future stage, by the opening out or unfolding of the enveloping structures. The more profoundly we examine the development of the simplest plant or animal, and still more so if we contemplate the process in the more complex beings, do we become satisfied that this process is peculiar to organisation.

On the principle that all the conditions of a question should be considered in attempting to solve it, we may ask what is there remarkable in the constitution of one of the higher animals, in addition to the mere chemico-physical mechanism and teleological adaptations of its frame, and in addition to the peculiarly organic peculiarities already enumerated ?—Assuredly its psychical manifestations. Without entering at present into the question as to the difference between the psychical constitution of the brute and the mind of man, this much cannot well be denied, that there is in the constitution of the brute an essence which is not material. The evidence of the existence of a psychical essence in the brute is necessarily indirect. We infer its presence, however, with sufficient certainty, by comparing its psychical manifestations with the conclusions at which we arrive by the exercise of our own peculiar self-consciousness ; and we are supported in our inference by the concurrent intuitive opinion of mankind in regard to it.

This psychical essence varies in its endowments in different species of animals. It is specific for each species, individual in each individual. It manifests itself less and less distinctly, and is evidently more simple in its character the lower it is in the scale of being. In plants, it is not manifested in proper psychical acts.

Here, however, it must be recollected, that in the embryos of the higher animals the so-called mind of the animal is latent ; and that in man, before birth, the entire psychical and spiritual elements of his constitution are in the same condi-

tion. The psychical essence exists only potentially in the embryo of the higher animals. It is suddenly and fully evolved after its birth by the influence of the senses under the peculiar conditions of the instinct. In man, again, it is more slowly evolved by the influence of the senses, conditioned by his peculiar spiritual self-consciousness.

I have alluded to the latent or potential condition of the psyche in the embryo of the higher animal and of man, for the purpose of showing that there is nothing unphilosophical in the admission of a psyche in the plant. We are quite entitled to state, as a legitimate hypothesis, that in every individual plant there is an indwelling psyche; more simply endowed than that of the lowest animal; specific for each species of plant, and therefore incapable of further evolution, never manifesting itself in psychical acts appreciable to us, and performing only the lowest function of the animal psyche, constituting the psychical form in the presence or midst of which the organisation is co-ordinated.

If, then, a psychical element be admitted to exist in every living organism, we may reasonably inquire how far its presence has to do with the organising process.

We know nothing of the mode in which mind acts on matter, or in what manner matter reacts on mind. We know, however, that both actions occur in the brain. A physical current, the result of polar forces, passing along a nerve-fibre, and reaching a group of connected nerve-cells, is immediately followed by, or contemporaneously accompanied by, a psychical condition—that of sensation with perception. But, what is more to our present purpose, we now know that another psychical condition—a determination of the will—is accompanied by, or immediately followed by, a physical act in a single nerve-cell, or in a group of nerve-cells, from which cell or cells there immediately proceeds along a connected nerve-fibre a physical current—the result of polar actions—which,

when it has reached a muscular fibre, induces its contraction —also a physical act.

In the present phase of science, it would be unphilosophical, and could not be admitted by the physicist, even as a hypothesis, were we to state directly that a psychical power and a physical force can act and react on one another. But, with such facts as I have already adduced, a mutual influence of some kind must be admitted. I am strongly impressed with the belief that on the cautious and philosophical investigation of this mutual influence depends the future elucidation of the peculiarities of organisation. At present I prefer stating the relation between the psyche and its organism as one of co-ordination. Its actual nature we shall probably never determine ; its laws we may presume to be within our reach.

I would here observe that the extent and nature of my subject, and the limits within which I am confined, have compelled me to state my views in a somewhat dogmatic style. To have treated it satisfactorily, the opinions of at least the principal philosophers and physiologists of ancient and modern times should have been adduced and examined in reference to the more important subjects discussed.* In the meantime, I will merely state, categorically, the views which I have endeavoured to embody in this lecture, in order that there may be no misconception regarding them.

Every living organised body—that is, every individual plant and animal, according to its kind or species—contains, or is contained in, a psyche ; which is not a mere co-ordinated system of material forces, but a distinct essence, the source, more particularly, of the psychical manifestations.

We are alike ignorant of the mode in which matter acts on matter, as of the mode in which mind and matter react. As, however, we do know that mind does act on matter, and conversely—as in the instances of the will inducing physical

* Note VIII. p. 322.

currents in the cells and fibres of the brain and spinal marrow; and of physical currents in the spinal marrow and brain inducing sensation—it would be equally unphilosophical to deny, as to assert, that psychical power and physical force do immediately influence one another in the living organised body; or to assume, as an element in physiological research, that the indwelling or containing psyche is the source of organic form, or that it influences chemico-physical forces to that effect.

I therefore state, provisionally, that the corporeal structure of the organised being is co-ordinated with the specific endowments of its psyche, so that they act and react harmoniously.

The psyche is latent in the plant, as it is in the higher animals during its embryo condition.

In the animal series, the psyche, distinct for each individual, and specific for each species, is more highly endowed, according to the elevation of the animal in the scale.

The psyche regulates the actions and habits of the animal in accordance with its corporeal structure; and the conditions of its existence has a code of laws, to which we apply the term instinct.

The psychological constitution of the animal, and its peculiar form of consciousness, are conditioned by the instinct.

It is unphilosophical to entertain the question in regard to the mortality of the psyche of the brute.

Physiological considerations, psychological and philosophical induction, and the precise statements of Revelation, prove that man, in addition to his body, with its chemico-physical properties, and his psyche, which is the co-ordinated form of his organisation, and the source of his instincts, appetites, and passions, possesses also his *pneuma*, which constitutes his personality, is the essence of his peculiar self-

consciousness, the ground of his proper intellect, and the conditioning element of his moral faculty, and of his religious belief. It is the possession of this *pneuma* which distinguishes man from the animal. Possessing, like the animal, a body and a psyche, he may descend, if he will, to the level of the brute. But he has also had it put in his power, in virtue of his pneuma, to participate in the conditions of a higher sphere of existence.

I am compelled, therefore, to assume, as the guiding principle of my physiological studies, that the living organism is a co-ordinated system of psychical powers and physical forces; and that, except as part of such a system, organisation cannot occur.

Note I.—p. 286.

"THE GRADUAL AUGMENTATION."

All the subjects, regarding some of which man has had a certain amount of knowledge revealed to him, and for inquiry into others of which he has had appropriate faculties bestowed upon him, form parts of a whole which is throughout in perfect harmony with itself.

The human mind, although limited in its capacity and capable of acting only to the extent of the powers bestowed upon it, is, nevertheless, within its own sphere of capacity and of action, formed and endowed in perfect harmony with that whole, regarding which, it is permitted to inquire, and to obtain knowledge.

All acquired knowledge, properly so called, must therefore be in harmony with the whole; and the entire mass of human knowledge, revealed and acquired, in its proper form, at any given epoch, must be in accordance with that whole, of which in fact it constitutes a part. Acquired knowledge is the result of inquiry by individual minds, into subjects more or less numerous and distinct. But, as all minds have the same general constitution, and are regulated in the process of inquiry by the same laws of thought, and as, moreover, they are all formed in harmony with that whole,

the separate parts of which they are investigating; the fragments of knowledge acquired by each, however discordant they may appear, are yet, in fact, only apparently so.

These fragmentary acquisitions are all necessarily related to the common centre of the whole. As, therefore, they increase, or when the flexes of which they form parts extend, they must do so towards the centre. In the process of convergence they must necessarily, according to their proximity to one another, sooner or later coalesce, in which act their former apparent discrepancy vanishes, and their results assume their real appearance as parts of the common whole.

Note II.—p. 286.

"ORIGINALLY INDEPENDENT."

The independent origin of the different departments of acquired knowledge is a consequence of the finite conditions of human thought. These finite conditions, necessarily excluding from a central point of view, and compelling the inquirer to examine any subject from one aspect only at a given time, can permit a knowledge of that subject which, although true, is only partial. He may, for instance, acquire a knowledge of a given subject from the chemical point of view, from the electrical, and from the mechanical. But these three kinds of knowledge regarding it are in a great degree independent, and must continue to be so, until chemistry, electricity, and mechanics shall have coalesced more completely than they have yet done, and thus permit a view not from a mere chemical, electrical, or mechanical, but from a new and more central position.

Note III.—p. 286.

"THEIR PERMITTED POSITIONS."

Absolute knowledge must have a centre, from which and to which, all its parts must be necessarily deducible and referable. If human intelligence could push its inquiries forward to that common centre, the result would be knowledge of the Infinite. The consciousness of the impossibility of approaching that centre by the ordinary exercise of the human faculties has induced the various

attempts which have been made by philosophers to explain the derivation of created things, and even to unveil the nature of the Deity, by assuming to contemplate them from the centre of Absolute Being. But as human intelligence can neither reach that centre from the periphery, nor assume it at will, and is unable, therefore, to view the whole from a central position, human knowledge must ever remain only fragmentary. It can only amount to as much as has been immediately revealed to man, together with the continually-increasing but finite acquisitions made by the exercise of his definitely limited faculties.

Knowledge is augmented by a twofold process. It is the result of the exercise of the active faculties, conditioned by the laws of the consciousness. In as far as it results from the exercise of the former, it may be conceived to be approached from the periphery; as conditioned by the latter, it may be conceived as related to the centre. But as the active faculties are limited, and the consciousness strictly conditioned, it is evident that at no time can acquired knowledge be other than fragmentary.

Each department of acquired knowledge will therefore, at any given epoch, have reached its permitted position in the mass; that is to say, such a position in relation to the centre, as the conditions under which the human faculties are limited permit it to assume. "Conscious only of—conscious only in and through limitation, we think to comprehend the Infinite, and dream even of establishing the science, the *nescience* of man, on an identity with the omniscience of God. It is this powerful tendency of the most vigorous minds to transcend the sphere of our faculties, which makes a 'learned ignorance' the most difficult acquirement, perhaps, indeed, the consummation of knowledge." "There are two sorts of ignorance; we philosophise to escape ignorance, and the consummation of our philosophy is ignorance; we start from the one, we repose in the other; they are the goals from which and to which we tend; and the pursuit of knowledge is but a course between two ignorances, as human life is itself only a travelling from grave to grave."—(*Sir William Hamilton's Discussions on Philosophy*, etc., pp. 36 and 601.)

Note IV. p. 286.

"ABSORBS IN ITS PROGRESS."

The gradual absorption of one science by another is merely a higher form of induction, and a necessary consequence of the finite nature of the human faculties. We acquire knowledge as we ascertain the peculiarities of a country which we enter for the first time from the sea. We are compelled to approach all subjects of inquiry *ab extra.* We become aware at first only of their salient points; as we advance in our examination, the points dilate into masses; and as we at length fairly enter a particular district of investigation, the points and masses blend more or less completely into one harmonious whole, or confuse and distract for a time by their number and complexity. The isolated phenomena and observations which gave origin to magnetism, electricity, galvanism, electro-magnetism, thermo-electricity, organic electricity, and the physiology of the nerve-fibre, were salient points of a number of apparently independent subjects, but which, in the progress of discovery, have blended more or less completely with one another, and will undoubtedly, at no distant period, form one continuous whole. And so it is with every other department of inquiry. The mind is therefore necessitated, from its finite nature and the laws of its constitution, to prosecute inquiry in different directions and from different aspects, and thus to amass for itself departments of knowledge, at first independent, but destined sooner or later to blend together. This blending together of different departments again results from their accordance with the whole (τὸ ἕν), as far as we are capable of investigating it. We can never comprehend the τὸ ἕν; but we can apprehend as much of it as our senses and self-consciousness, framed in harmony with it, are fitted to reach. And thus it is that acquired knowledge must ever be fragmentary; that it has originated, and will originate, in centres apparently independent; which again, in as far as our faculties permit, will expand and blend into masses, which will be but portions of the infinite whole.

Note V. p. 288.

"THE MASS OF PHYSIOLOGY, AS USUALLY UNDERSTOOD."

The older philosophers applied the term physiology to the so-called general science of nature, and nearly in the same sense as the Germans at present employ the terms naturphilosophie and naturwissenschaft. (Naturphilosophie is employed to designate the science of nature in its widest sense, from the ontological point of view, and consequently by the philosophers of the idealistic schools. Naturwissenschaft is applied to the subject viewed as Inductive Science—that is, viewed in a strictly scientific sense.)

Note VI. p. 288.

"FUNDAMENTALLY DISTINCT METHODS OF RESEARCH."

The subjects of Human Inquiry may be arranged in four groups, distinguished from one another by the fundamentally different modes in which their constituent facts, usually so-called, are attained. These groups are mental and moral, or, to employ the term in its original sense, Metaphysical subjects; and subjects of Mathematical, Experimental, and Observational research.

The constituent elements of Metaphysical subjects of inquiry, are reached by the exercise of the Human self-consciousness, turned inwards on itself. The facts thus attained are facts attained by consciousness alone. The ultimate facts of Moral Science are, moreover, not only recognised by the consciousness as "the law engraved on the heart," but are, in addition, made known by direct revelation.

The constituent elements of Mathematics are derived from the ultimate universal truths of Space, Number, and Limit; and which are, therefore, immediately recognised by the consciousness.

The constituent elements of the Experimental sciences are reached by experiment, under the guidance of legitimate Hypothesis; that is, by means of a process of tentative, constructive, and therefore active examination through the senses.

The constituent facts of the Observational sciences are procured

by the similar, but comparatively passive process of examination through the senses, termed Observation.

It is to be observed that there is, in general, a great difference in the facility with which individual minds can work in these different modes of procuring and arranging data. Certain minds work easily in Mathematical, others in Experimental or Observational research. Few minds are capable of that peculiar power of abstraction necessary for Metaphysical and Psychological inquiry. It is to be noted, also, that there are comparatively few minds which combine two or more of these powers; and such minds are, invariably, under favourable circumstances, the most successful in conducting research.

These fundamentally different powers or capabilities are innate; certain minds being naturally more or less highly endowed with one or more of them; but every sound mind possessing them to a greater or less extent. Each of these powers, therefore, after its kind, is capable of being developed by judicious training. The evolving and exercise of these powers, in due proportion, constitutes a primary element in a sound general education; while the education for particular professions demands as complete a development as possible of at least one or more of them.

All scientific, or other inquiry, is, however, fundamentally regulated by the laws of thought. For these laws, as they are the conditions under which the Human Intellect works, cannot be dispensed with, and consequently constitute the logical process in every train of inquiry. Every sound intellect is necessarily—that is, is instinctively regulated, more or less, by the Laws of Thought; but the extent to which it is so regulated, depends upon that assiduous training, with this special object in view, and which ought, therefore, to constitute another of the primary elements of a sound general education.

There are, therefore, in all inquiry, two steps to be taken. The elements or facts of the question, of whatever kind these elements may be, must be laid hold of; and the logical process must be brought to bear upon them for further analysis or reduction, and reference to their proper position in the system. There is a difference between metaphysical and mathematical inquiry on the one hand, and experimental and observational on the other, in the

mode in which these steps are taken. In Metaphysical inquiry, the mind examines through her self-consciousness, her own constitution, and the necessary truths and principles of reason—that is, knowledge and existence. She does so in the full assurance that her constitution is in exact accordance with these necessary truths and principles. In the Mathematical she also examines, by means of her self-consciousness, necessary truths; for the elementary data of the mathematician are merely necessary truths in relation to number, space, and limit. She proceeds in such inquiries with perfect confidence in the stability of her data, because her own constitution is in exact accordance with all truth. It thus appears that metaphysics and mathematics, dealing with necessary truths, require, for their successful prosecution, merely an aptitude for seizing their fundamental elements; and the correct application of the logical and inductive processes of the intellect to these elements. But, in experimental or observational inquiry, the mind must act through the senses. In dealing with matter, in all its forms, the mind cannot dispense with those channels of information, through which alone, according to her constitution, she is enabled to apprehend external nature. The so-called facts of Observational or Experimental science reach the mind, therefore, through the senses, and are consequently characterised by all the ambiguity inseparable from their medium. They are apparent, not real; they are phenomena, not noumena. They differ from the elements of metaphysical and mathematical knowledge, which are necessary and immediate truths, in this respect, that they must be interpreted—that is, reduced to a thinkable form, or introduced to the sphere of necessary truth. The process of reduction to a thinkable form must be effected in every instance of experimental or observational inquiry, from that of the most elementary phenomena up to those of the solar system. It constitutes the inductive method, in its ordinary acceptation; by means of which alone mind advances in the midst of surrounding phenomena, and reduces them to the absolute truths of Force—Space—Time—Number—and Limit. Be it observed, however, that this distinction between metaphysical and mathematical inquiry, on the one hand, and experimental and observational on the other, does not consist in the immediate apprehension of noumena in the case

of the former, and in the immediate analysis of phenomena in the case of the latter; but merely in the double analysis which the latter kind of inquiry involves—or more correctly in the extension of the analysis to the phenomena themselves. The inductive process must be followed in both kinds of inquiry; but in the metaphysical and mathematical it rests immediately on ultimate and necessary truth, while in the experimental the phenomena themselves must be analysed, so as to be introduced into the sphere of ultimate and necessary truth. The inductive process is not, therefore, confined in its application to experimental and observational, but extends to metaphysical and mathematical inquiries. The induction, in the case of the latter, lands at once in necessary truth; while, in the former, the phenomena themselves, on which the inquiries are based, must be subjected to the analytical and inductive processes, before the subject can assume a thinkable form.

The inductive process, more particularly as employed in experimental and observational research, consists in the provisional construction or assumption of a law applicable to the phenomena, and in testing this assumption by renewed experiment or observation. If, after sufficient trial or observation, the assumption holds good, and, more particularly, if it indicates, and, on trial, reveals results not previously known or anticipated, it may be safely held as established in its present form, and the so-called facts it involves may be said to be explained or inducted.

The assumed or provisional law always involves some mediate or immediate form of ultimate or necessary truth, upon which depends its capability of being thought. The human mind is indebted for its power of framing such hypothetical or provisional laws, with the view to the discovery of actual laws, to the endowment of a divine element by its Creator, in virtue of which it is formed in accordance with all truth, and in harmony with all created things, and so is enabled to see, dimly it is true, into surrounding phenomena, but with sufficient clearness, when its gaze is legitimately directed, to seize upon their probable relations, so as to test them by necessary truth, and previously acquired knowledge, brought to bear upon them under the guidance of the laws of thought.

Note VII. p. 288.

"AND WITH THE PSYCHOLOGICAL."

Psychology is to be carefully distinguished from Metaphysics, which is the science of the relations of Being, Knowing, and Thinking.

Metaphysics have no place in the province of Natural History; but Psychology is one of those sciences from which the naturalist is obliged to borrow, in his efforts to investigate the properties of organised beings.

It is a great mistake to consider Psychology as a subject, mystical, vague, unsubstantial, and affording nothing which can be applied to practical purposes. On the contrary, it is a purely inductive science, dealing with facts and their generalisation. Psychology, however, differs from ordinary inductive science in this respect, that the facts with which it deals are not attained through the bodily senses, but by the mental consciousness.

In the prosecution of ordinary inductive science, the mind throws herself out, as it were, upon external nature, even upon her own organism, if that be the subject of her inquiry. In this act she becomes aware of certain so-called facts, to her at first merely phenomena.

But, in the investigation of her own constitution, she turns in upon herself, and attains the facts of Psychology, not by sense, but by consciousness. The facts of Psychology are not phenomena, but noumena, in the broad sense of the term. They are not, however, less certainly facts on that account.

The advance of Psychology, as a department of Anthropology, is opposed by no difficulty other than that inherent in the nature of the subject. But as a department of general Zoology, it has to encounter difficulty in collecting facts.

We must not, however, be repelled by this difficulty, or hold with Bonnet that philosophers will make no progress in the subject "until they have spent some time in the head of an animal, without actually being that animal."

We determine the characters of the mental acts of our fellow-men, by observing certain corresponding corporeal actions.

We may therefore reasonably expect, by the careful investigation of the habits and actions of animals, aided by cautious generalisation, to derive much important psychological knowledge. Such knowledge will ultimately assume the form of a sub-science—Comparative Psychology.

The facts of Human Psychology are attained directly through the consciousness; but the generalisations of Comparative Psychology must necessarily continue to be indirect.

We must, therefore, compare the facts and laws of the Psychology of man, with the indications or manifestations of apparently similar facts and laws in the brute.

It will at once be admitted, that the central fact of our psychical constitution is the existence of a power within us, in virtue of which we possess the faculties of Knowing, Feeling, and Willing.

To this power we may apply the term Intelligence—employing the word in the broad sense of which it is susceptible.

That a corresponding power exists in the brute will, I believe, be generally admitted.

There appears, however, to be a very marked difference between this power as it exists in man, and even the highest form of it in the brute.

In man it is fully evolved, capable of being scrutinised as an object by its possessor.

In the brute it is semi-evolved, and, as we shall in the sequel find grounds for concluding, unconscious of itself.

It would appear to exist in the simplest forms in the simplest animals. As we extend our observations up the animal series, it appears, as recognised by its manifestations, in forms more and more complicated, in species above species, but never reaching, even in the Orang, the stage of self-consciousness.

Intelligence always manifests itself in connection with certain organs and parts of the animal.

It is not, however, produced by, or secreted from, these parts or organs, but only, as has been already stated, evolved parallel to, and in harmony with, their development.

In the study of Comparative Anatomy, much success has been attained by commencing with the examination of the simplest forms, and extending our observations upwards, in a series of increasing complexity.

A similar course naturally suggests itself for the prosecution of Comparative Psychology.

Selecting animals with the simplest structure, and the least complex external relations, and applying to the explanation of their psychical manifestations the elementary facts and laws of Human Psychology, we may reasonably expect indications of the nature of such manifestations.

As we are compelled, at the same time, by the nature of our subject, to proceed from the knowledge of our own psychical constitution, let us inquire what is the first stage in the evolution of our own intelligence.

It would appear to commence at birth. It awakens contemporaneously with the arrival at its seat of certain of those so-called impressions made upon the surface of the body of the infant by the new medium into which it has entered.

Some of these newly-arrived impressions are intended to cooperate in the economy of the organism (reflex actions); but others are immediately related to the awakened intelligence, and with them only we have at present to do. They are the impressions on the organs of the senses.

Of these latter impressions the intelligence becomes aware. In technical language, sensations are produced. The being experiences sensations.

To ascertain the nature of sensation, we must analyse its so-called phenomena in our own consciousness, and combine the results with what we know of the economy and actions of the corresponding organs of the nervous system.

Sensation may be defined to be apprehension, by the intelligence of impressions transmitted to its seat from objects in the surrounding medium, or in its own organism.

This apprehension would appear to be immediate; that is, the apprehension is not a process; for, as Sir William Hamilton has pointed out, we cannot discriminate Sense from Intelligence.

A process must be admitted, however, in the act of sensation. It would appear to consist of three parts:—

1. The impression on the organ of sense.
2. The transmission of this impression along the nerve.
3. The recognition by the Intelligence of what has been trans-

mitted along the nerve to the vesicular matter of the central nervous organ.

This process of sensation, then, lies partly without, partly within, the consciousness. The impression on what is called the sensible part, and the transmission along the nerve, are beyond the consciousness, and would continue so were its passage interrupted; but when it affects the nervous centre, it enters the region of consciousness, it becomes recognised, and assumes the form of a psychological fact.

It must be observed, however, that the apprehension now under consideration is entirely subjective. The intelligence merely apprehends an affection of itself. There has taken place no apprehension whatever of the object which produced the impression transmitted and recognised.

The apprehension of the object itself requires a higher phase of intelligence. It requires a power of interpreting the sensation, or of apprehending it in a form peculiar to the kind of sensation, whatever that may be.

The intelligence now no longer apprehends a sense—a mere affection of itself—but it apprehends an object from which proceeded the impression which induced that sense.

This peculiar intuitive power possessed by the intelligence of objectifying a sensation, is denominated, in the language of ancient Psychology—Perception.

We have now reached the point at which may be recognised the difference between the intelligence in man and in the brute.

From the first moment that the intelligence of an animal is awakened by sensations, and contemporaneous with the corresponding intuitive perceptions, it becomes conscious. It becomes conscious of external objects, as out of itself, and as having certain relations to itself. It is able immediately and directly to determine the position and other relations of the objects it perceives, in relation to the surface of its own organism.

It is enabled to do this immediately and directly, under the influence of a power, acting according to certain laws — a power to which we apply the collective term—Instinct.

In man, again, where his intelligence has been awakened by sensations, and contemporaneous with the corresponding percep-

tions, consciousness, the essence of intelligence, comes into play. We have already seen how the awakened intelligence or consciousness of the brute, under the guidance of instinct, at once enables it to determine, with precision, its relations to external objects. But the newly-awakened conscious intelligence of man is unable to effect this for him. He refers all his perceptions of external objects to the surface of his own organism; he is unable to determine their exact position in space.

If, however, he is at this stage of his career more helpless than the brute, there has already begun to be evolved within him a power which completely distinguishes him from the lower animal, and which will not only speedily put him on a level with it, in relation to external objects, but which will, if employed aright, raise him indefinitely in the scale of intelligence.

This power is a property conferred on the human intelligence by its Creator, in virtue of which it is capable not only of perception, but of apperception. It is not only conscious, but self-conscious.

In the brute, consciousness is in relation to the objects perceived; the consciousness of self in the animal extends only to the not confounding of itself with those objects. In technical language, the animal can apprehend the object only; it cannot apprehend the subject.

Man, again, is conscious, not only of the object perceived, but of the self which perceives. He can apprehend the subject as well as the object. He is to himself, in the technical language of metaphysics, a subject-object.

If we assume, as it would now appear we are fully entitled to do, that the brute is only capable of objective consciousness, its so-called intellectual processes resolve themselves into mere suggestive acts. Its so-called thoughts, or trains of thought, are merely individual acts of objective consciousness connected by the determining law of its instinct. These acts of objective consciousness may be immediate—that is, induced by the actual presence of the object; or they may be mediate—that is, reproductions of acts of objective consciousness, through the memory or imagination. The brute is undoubtedly capable of memory and imagination; but its acts of memory and imagination are, like its other acts of

consciousness, individual and objective acts—that is to say, they are induced by the presence of an object or exciting cause, and are connected in the most direct manner by the instinctive laws of its constitution. The memory and the imagination (which is dependent on the memory) of the brute may be compared to those systems of Mnemonics which are resorted to by persons who have not acquired the faculty of grouping under general principles the facts which they desire to remember.

The apparent intellectual processes of the brute are, like its acts of memory and imagination (Mnemonic and Phantasmic acts), merely individual acts of objective consciousness, connected by the necessary elementary psychical consecution. A recollection or a phantasm immediately follows an objective excitement; and an apparent intellectual conclusion is only a single, necessary, and terminal movement in advance of the primary psychical impression.

If we assume, indeed, the absence of self-consciousness in the brute, we must admit the corresponding absence of intellectual movement. The simplest intellectual process involves at least three steps—the formation of a general notion or concept, the predication of the subject of the process in the concept, and the necessary conclusion. But a concept is an abstraction, a mere subjective form under which we group together any number of objects by the points in which they agree. It requires, therefore, for its attainment a self-conscious power. In like manner the predicating anything of an object, or of the subject of a thought, and the consequent conclusion, involve acts of self-consciousness. Every so-called act of thought, or intellectual process in the brute, must therefore, if we assume the absence of self-consciousness, be reduced to the level of an act of suggestion.

In the want of self-consciousness, and irrespective of the more or less non-adaptation of the appropriate organ, we have an explanation of the absence of speech even in the highest form of the brute. Language is an organon developed in exact harmony with, and presenting a complete counterpart to, all the arts, movements, and processes of thought. Words, relative terms, and propositions, are merely the forms in which language represents the corresponding intellectual movements. The various signs and

noises indicative of the Appetites, Affections, and Passions of the lower animals constitute, indeed, an elementary form of Language; but it is entirely destitute of the discursive element which, distinctive of thought, exhibits itself in the relative terms of logical speech. The so-called Language of the brute is merely a succession of signs, each sign significant of a particular appetite or emotion, and primarily induced therefore by an objective excitement.

The human self-consciousness is possessed of two sets of faculties—those subservient to knowledge, and those subservient to impulse. These two sets of faculties are grouped around the free will, which comes into play in the exercise of the first group, and in the regulation as well as exercise of the second. The intellectual faculties of the self-consciousness are powers awakened in harmony with certain impressions, on which they react; the resulting processes being carried forward by the determination of the will, under certain conditions. The impulsive faculties of the self-consciousness are feelings induced by certain impressions, and involving, according to their kinds, attraction to or repulsion frem certain objects; the attraction or repulsion, in relation to the will, being conditioned by the conscience.

In virtue of his self-consciousness, therefore, man is enabled to discover the laws of Nature and of his own constitution; and he is, by the same means, enabled to judge of these laws as being true.

In virtue of conscience, that peculiar condition of his self-consciousness, in relation to his impulsive faculties, he is also enabled to determine when he ought to repress his appetites, passions, and emotions. He has a Free will, but he has also a sure guide for the regulation of it.

We have had reason to conclude that the brute is not possessed of self-consciousness, that it is only conscious. We are obliged to admit that, unconscious of its psychical processes, it cannot regulate them, nor can it be possessed of a conscience to control its appetites and emotions.

Man ought to act under the influence of his spirit (πνεῦμα). The brute invariably acts under the influence of sense (ψυχὴ or σάρξ).

The emotions or impulses of the brute are thus regulated by

instinct only. The animal must obey them, and it does so. Its emotions, therefore, are deficient in the subjective element. Like its so-called intellectual operations, they are related only to their peculiar objects.

Having thus endeavoured to secure a philosophical basis for the psychology of the brute, or comparative psychology, as a department of general zoology, a brief analysis may next be attempted of the appetites and so-called emotions and passions of the animal.

In the appetites, emotions, and passions, the conscious, as well as the self-conscious being, would appear to anticipate, with manifestations of satisfaction or disgust, pleasure or pain, in their consummation.

The appetites, emotions, and passions of the lower animal may be grouped, with reference to their manifestations, into appetites which are allied to sensations, passions which are related to perceptions, and social impulses which exhibit a resemblance to understanding.

The appetites are principally related to the immediate well-being of the organism. The primary appetites are connected with certain sensations to the fulfilling of the objects of which they are impulsive :—they are the appetites for food, drink, air, warmth. These primary appetites, along with certain instinctive impulses, such as the desire of exercise, as exhibited in the movements of animals in a state of freedom or confinement, and in the use of the means provided for self-defence, constitute a group of psychical conditions conducive to the preservation of the individual.

A second group of psychical powers are related to the preservation of the species. This group consists of the sexual instinct, and the various interesting forms of the pædagogic instinct, such as nidification, incubation, suckling, and the so-called education of the lower animal by its parents.

A third group of psychical conditions, analogous to the passions of the self-conscious being, consist of the so-called anger and jealousy, revenge, gratitude, grief, emulation, desire of approbation, love, and friendship, of the lower animal.

A fourth group includes the social impulses, subdivided into

the family instincts and the communal instincts. The former includes the psychical manifestations exhibited during pairing, the preparation of the common dwelling, the preparing of food, defence of the family, the arrangements for propagation and rearing of young.

The latter consist of the Psychical manifestations exhibited during the temporary or imperfect associations of animals for amusement, for pairing and breeding, for migration, for hunting; and of the remarkable psychical manifestations exhibited by those animals which form perfect communities or polities.

In this part of the subject an important consideration is introduced touching the relation between what was denominated a psychical community, such as exists in the hive or ant-hill; and an organic community, such as presents itself in a composite organism, as, for instance, a Zoophyte or Phytophone.

It is very important that it should not be supposed there is a process in the recognition of the externality of an object by the human intelligence, or that this recognition results from a previously-existing recognition of self. The two presumed recognitions are two aspects of the same fact. In the same moment that the human self-conscious intelligence apprehends the influence transmitted from an external object—or, in technical language, in the moment of sensation—it apprehends itself also.

On the other hand, the recognition of the externality of the external object by the animal is effected in the moment that the impression produced by that object is apprehended by its intelligence—in the moment of sensation—in virtue of its animal or instinctive constitution, which is unconscious of self, but cognisant of the opposite pole—the externality of the object.

The instinctive element already alluded to as conferring on the animal the faculty of recognising immediately the externality of external objects, confers on it also many other remarkable faculties. To these I shall afterwards direct your attention, but at present it is necessary that I should point out what appear to be the distinctive characters of this peculiar element which reigns supreme in the brute.

Our space will not admit of an extended analysis; but we may sum up the result in the following definition of Instinct.

Instinct is a collective term applied to those laws, in virtue of which the psychical endowments of the animal are so adjusted in reference to its organism with its functions, and to all the necessary and contingent circumstances in its existence, as to enable them to work together harmoniously in the adaptation of means to ends, without self-consciousness.

On the other hand, that peculiar principle in the constitution of man, which acts independently on his instincts, and in virtue of which he is conscious of self, capable of apprehending the objects around him as external to self, enabled to exert his corporeal and psychical powers in the accumulation and co-ordination of ideas and their signs ; but, above all, capable of determining between right and wrong ; of recognising his own immortality ; and his dependence, as well as the dependence of all around him, on his and their Divine Creator, is an intelligence altogether different in kind from the instinctively co-ordinated intelligence of the brute.

The bee, in the performance of its work, unconscious of self, but capable of exerting its will, and determining its acts, invariably does so under the unerring guidance of a plan or code of rules, sufficient for, and co-extensive with, all the acts, and the succession of these acts, necessary and contingent, which it is required to accomplish, within its own sphere, in the general polity of the hive. It is neither a chemist, a geometrician, an architect, nor a politician. It, nevertheless, unconscious of the regulating principle, but under the guidance of the laws which control its psychical economy, fulfils its scientific, artistic, and political functions, with unerring accuracy and without previous training.

When man enters the sphere of his present existence, that peculiar principle, which is henceforward to regulate his psychical economy, is potential only, not in actual operation. Coming into play contemporaneously with the apprehensions of sense, it is so unprepared for the regulation of the economy of the individual, that he cannot even employ efficiently his organs of sense, or perform of himself many necessary functions which the animal, under the control of the instinct, fulfils at once.

But, by degrees, and contemporaneously with the indications of sense, it becomes evolved until the individual is capable of moving in a sphere, and of reacting on surrounding objects, in a manner

and to an extent which the possession of the highest instinct could not have enabled him to reach.

The plan or code of rules by which the psychical economy of the animal is regulated is laid down and determined by a power beyond its control or consciousness.

The complex but harmonious and ever-developing system of rules and laws, which is the result of the evolution of the regulating principle in man, in relation to external objects, would appear to be, at any one moment, the exact counterpart of as much of everything external to itself as it has been awakened to in correlation with the recognitions of sense. Hence, however, it is to be noted, that the animal must obey, and does act up to, the laws and rules of its regulating instinct.

But the regulating power in man is free. He has had a free will bestowed upon him. He may follow the dictates of his self-conscious regulating principle, or he may act contrary to them.

Into the consideration of this peculiarity of the Human Constitution I do not enter, as not bearing on our present subject. I must, however, direct your attention to the characteristics and development of those powers of the Human Intelligence which require to be borne in mind, while we are engaged in the study of the Psychical manifestations of the lower animals.

In the first place, it is to be observed that self-consciousness involves the faculty of judgment. "It cannot be realised without an energy of judgment." Self-consciousness is in fact an exercise of Thought. It involves a comparison and a judgment regarding two things, neither of which we can think down or out of existence—namely, the self which thinks, and the self which is thought of.

Again, in the act of Perception, we are not only conscious of *self* but of a *not-self*. We cannot disbelieve the one or the other. They are relative to one another, "each known only in antithesis to the other." Here again judgment is passed between the two terms. It is an act of Thought.

Then, again, we cannot think anything except under the condition of Time. Self-consciousness involves the judgment of *self* and of *not-self*, as being or existing in Time. With our utmost efforts we cannot think ourselves or aught else out of Time.

Time, indeed, is to us only relative. We cannot conceive an eternity past, or an eternity future; neither can we conceive Time compressed into nought or annihilated. Time is to us, therefore, only apprehensible as a condition under which we think. Time is a condition of Thought.

In the same manner, Space is to us only another necessary condition of Thought. In itself it is absolutely inconceivable. We can only think of it as "an indefinite whole," or "an indefinite part." We can only conceive of it while passing a judgment regarding the relation of things as they are in it—as they are external in relation to one another, or as they are one within the other.

It is evident that the relations of things thought of under the conditions of Time and of Space involve the judgments of Duration and of Motion.

Thought, under the condition of Space, involves the judgment of matter as not annihilable. We cannot conceive aught as capable of being expanded in Space, or compressed Space into annihilation.

The irresistible judgment of Causality is passed by our self-consciousness by virtue of the necessity it is under of judging of existence under the condition of Time. We cannot think of a thing but as an existence. We cannot think of a thing except under the condition of Time; that is, we are under the necessity of considering it as only a new form of what existed before it. Therefore we cannot think of it as absolutely commencing *per se*. We are able to conceive the creation of a world, this, indeed, as easily as the creation of an atom. But what is our thought of creation? it is not a thought of the mere springing of nothing into something. On the contrary, creation is conceived, and is by us conceivable, only as the evolution of existence from possibility into actuality by the fiat of the Deity.

We have up to this point assumed that the brute is not self-conscious; that it is only conscious; that it only does not confound itself with the objects it perceives.

If this be the case it must be inferred that the animal intelligence does not pass a judgment in an act of consciousness. The act is intuitive. It is not an act of thought.

If so, also, time cannot be a condition in any act of the animal

consciousness. Duration and causation are conceptions impossible for the animal intelligence; neither can the relative conception of space, or the secondary conceptions which flow from it, be possible for a consciousness not conscious of self.

As, however, these presumed distinctions between the consciousness in man and in the brute are of primary importance in comparative psychology, we shall proceed to inquire whether there is any mode of procuring—not direct evidence, for, from the nature of the subject, that is, as we have seen, beyond our reach—but cumulative although indirect proof, such as must put the matter beyond question.

This matter cannot be discussed at length in this note. A single example will suffice as an illustration of the method by which the indirect evidence of the nature of the consciousness of the brute may be attained. For this purpose the difference in the modes in which the use of the organ of vision is acquired by man, and by the lower animal, may be examined.

In man every act of sensation or perception, although actually occurring in the brain, is referred to the peripheral extremity of the nerve filament excited, to which extremity the exciting object is also referred (primarily), whether it acts on that extremity immediately or mediately.

Objects seen by the infant are, therefore, at first referred by it to the peripheral part of the organ of vision—that is, to the eyeball. The sensation as well as the perception of the object are both—if the expression may be allowed—located in or on the eye itself.

But the infant acquires the faculty of seeing objects not as in contact with its own organism, but in their relative positions in Space. This faculty is acquired by a process of investigation, the results of which are retained by continued practice, while the steps of the process by which they were originally procured have escaped from the developing, and therefore comparatively weak memory of the child.

The explanation of this process involves the consideration of a number of physiological and of psychological elements. The faculty which the human being possesses of perceiving the relations of objects in space, depends physiologically on the mosaic structure of

the retina, on the greater visual delicacy of the central retinal spot, on the relative position of the two eyes, and on the muscular sense ; and, physiologically, on the faculties of attention, memory, and conception under the conditions of thinking in space.

The mosaic structure of the retina permitting only the sensation and perception of a single point of light for each compartment of its surface, must necessarily afford the immediate means of conception of breadth, or of transverse and perpendicular separation, under the condition of thinking in space. The mosaic structure of the retina will thus at once, and without any movement of the eye or head, afford to the infant the means of judging of the separation of two points of light in the field of vision.

But much more extended and precise conceptions of the relations of breadth, or of transverse and perpendicular separation, are acquired through the muscular sense in the movements of the eyeball and head. These movements may be stated, generally, to have as one of their more important objects the bringing of the central or most delicate part of the retina opposite to each part of an object in succession. These successive movements constitute, in fact, a process of palpitation, during which the central spot, or most delicate part of the eye—considered as an organ of touch—in combination with the muscular sense, is successively brought into contact with the object examined. Through its faculties of attention, memory, and conception, under the conditions of thinking in Space, the mind stores up, and retains, in their proper relative positions, the successive perceptions it has acquired by the successive mediate applications of the central spot to different points of the object looked at, and in this manner is enabled to piece them together, so as to frame a conception of the object as a picture—that is, as consisting of parts, all situated in a plane transverse to the axis of the eye.

The self-consciousness of the infant now acquires the faculty of detaching its visual conception of an object from its eye. It has hitherto seen it as a picture in a transverse plane, and *at the eye.* It has now to see it—that is, to conceive of it through visual perceptions—as a solid object (if it should be a solid object) in its proper position in relation to other objects in Space.

Two means conduce towards this end : the position of the two eyes, and the exercise of the muscular sense.

It has been already stated that the immediate means of conception of breadth, or of extension in the transverse plane of the eye, is primarily afforded by the mosaic structure of the retina. In like manner, the means of conception of extension, in any direction, cutting the transverse plane of the eye, is supplied by the position of the eyes in front of the Human head. The Infant, when using both eyes, contemplates two aspects of every solid object, or two aspects of the entire scene before it. These two aspects afford two pictures in planes at an angle to one another, and consequently conceived of by its intelligence under different relations of space. It involves in its combined conception of the object or scene all the relations of Space, which are fundamental or necessary to its laws of Thought. It conceives of the objects seen in the three relations of length, breadth, and depth.

But, as the conceptions of the breadth and depth of an object as primarily derived from the mosaic structure of the retina, are extended and rendered more precise by the muscular movements and sense of the eyeball and head; so, in like manner, the full advantage of the arrangements for binocular vision is dependent on the use of the same means.

But the most important accessory to the Human eye is the Human hand. The Human hand is formed in absolute harmony with the conditions of Human thought. It is an instrument expressly framed to act under it and for it. Psychologically considered, it is the principal channel through which we derive the means of framing our conceptions of the form of bodies. Towards this end, it co-operates with the eye, bringing to the aid of the latter the combined results of the sense of touch, highly developed, on the fingers and palm, and of the muscular sense of the entire limb. The peculiar manner in which the human thumb can be opposed to the fingers, and the entire hand folded around the object, as well as the specifically human manner in which the upper limbs can embrace an object or enclose a space, are, undoubtedly, related to the requirements of the human self-consciousness. They are the principal organical means by which the human intelligence reaches those motions of external objects, which, when thought under the conditions of Space, enable it to frame its conceptions of external nature.

Such is the process by which man is enabled to acquire the use of his organs of vision. He arrives at it by an intellectual process; that is, by a process which could only be carried on under the conditions of a self-consciousness.

The brute is enabled to use its eyes *at once*. If, therefore, it possesses any form of self-consciousness, this faculty is not called into play in relation to vision.

But so, in like manner, self-consciousness may be eliminated from other departments of its physical manifestation. Now, as a most remarkable economy in the use of means for the most numerous and varied ends is exhibited in every department of God's works, it appears to be opposed to this principle of economy, that the brute should possess a self-conscious intelligence, and yet be indebted for the use of its faculties to some power beyond that consciousness.

It appears to me, therefore, that we are of necessity led to the conclusion, even when uninfluenced by other considerations, that the brute is conscious of external objects only, while man cannot detach his consciousness of external objects from his consciousness of self. The brute is merely conscious—man is self-conscious.

Note VIII. p. 297.

"MORE IMPORTANT SUBJECTS DISCUSSED."

It is right to state that it was the author's intention to have very materially extended these notes in their Metaphysical and Psychological aspects, with the view of publishing the lecture with annotations, but he was led aside by other work.—Eds.

III.—ADDRESS DELIVERED TO THE GRADUATES IN MEDICINE.*

Gentlemen,—You have now attained a position in which you are henceforward to be engaged, not only in the study of medicine, but also in the practice of it. You have become responsible for a continued course of self-improvement, and for your efficiency as physicians. Having taken your places as members of one of the three professions, the collective erudition of which constitutes the whole liberal learning of a country, you are bound deliberately to consider the nature of the position you now occupy. It devolves on me, on this occasion, briefly to indicate to you the scope and character of the duties which that position entails.

If the clerical profession demands an extent of study, and occupies a sphere of action which bring it into relation with every department of learning, and all grades of society; if the erudition and the knowledge of mankind necessary for the accomplished lawyer cannot be definitely limited; it is still more difficult to determine the line of demarcation between the province of the physician and the ever-extending area of human knowledge and activity.

The training required for any of the three liberal professions is therefore properly considered as the completion of a thorough education; and thus, those three distinct departments of professional study are, from their essential character,

* This address was delivered on the 1st August 1859, when Professor Goodsir acted as Promoter for that year.—Eds.

dependent on that general philosophical training which constitutes the fundamental object of a university.

This comprehensiveness of study, characterising these three professions, is necessitated by the nature of their common object. Differing in importance, in accordance with their respective purposes, they have, nevertheless, this feature in common, that they have severally to do with human nature. The first has its sphere of action in the responsibilities and duties of human nature to its Maker, Preserver, and Judge; and has for its end the eternal happiness of humanity. The second is occupied with the responsibilities and duties due by members of the community to positive law emanating from supreme political authority, and has for its end the temporal happiness of humanity. The third devotes itself to the wellbeing of the corporeal frame, which, although not an essential, is nevertheless a highly important element of human happiness; inasmuch as on the condition of the body depends the due performance of the social duties of the individual and his efficiency as a member of the community.

The three liberal professions being thus directly devoted in common to the wellbeing of humanity, your share of the work is to determine the conditions on which health may be best attained, and to indicate or to supply the means thereto.

Health essentially consists in the harmonious performance of all the functions of the being. The conception of health can only be derived from our conception of life as manifested in organisation. In the lowest plant, up to man himself, we unhesitatingly, and as it were instinctively, assume the health of the being as the most perfect manifestation of its life. As health is then the end to be attained by the calling of the physician, life, and more particularly life in relation to humanity, must constitute his peculiar study.

It appertains to the very essence of a liberal profession that its practice can only be finally determined when its

principles have been ascertained. The principles of your profession are derived from the study of life and its conditions. Herein consists the chief difficulty with which medicine has had to contend. The very circumstance that vitality is subject to disturbance in direct proportion to the comprehensiveness of the conditions under which it is maintained, involves its study in complexities of a kind which do not oppose the advance of the science of inorganic nature. Vitality can only be investigated as it is manifested in individual organisms. Now, although the organisation of the individual is a perfect system in itself, it is not the less a system dependent on conditions external to itself. All its parts and actions are prearranged in reference to as much of what is external to it as its conditions of existence involve. It can live or subsist in any locality in which these conditions are provided for it. If, again, these conditions are in any way transgressed, or if they are withheld, a diminution of health, or the access of disease, or of death, necessarily supervenes. As with the individual so with the species, the existence and health of which depend at any given time on the presence and integrity of the conditions of its collective vitality. The localisation of all the various species, genera, families, and orders, of organised beings in space, and their existence or non-existence in time, are referable to this fundamental law of organisation. From this law also is derived what appears to be a general principle in medicine—*that diminution of health, and the existence of disease, are the direct results of the disturbance or removal of one or more of the conditions of health*, so that the whole extended subject of the phenomena, nature, and causes of special diseases and injuries resolves itself into the investigation of the immediate or more or less remote disturbances of the conditions of health.

A second general principle in medicine follows from what has now been stated. For it appears that *the removal of*

disease consists essentially in the adjustment of previously altered conditions of health, and that the part which you have to take in the recovery of those who may require your assistance is therefore altogether indirect and secondary.

If the conditions on which health and life depend were merely material,—if the forces which are at work within the organised system itself, and which associate it with the external medium in which it lives, were only such as the chemist and physicist can investigate and determine,—then the problem of health and longevity would be comparatively simple. The next difficulty in your art consists, therefore, in this, that within the living economy you have to deal with powers which cannot be measured, weighed, or subjected to calculation, but which nevertheless exercise an influence there co-ordinate with the working of its material forces. As this double sphere of action is the leading characteristic of the organised being, so it on the one hand affords the distinctive mark of organic science, and on the other constitutes the peculiar difficulty of medical art. Hence we may infer, as another general principle in medicine, that *in the treatment of disease, the adjustment may require to be, and in general must be, directed more or less as well to the psychical as to the physical conditions of the case.*

As man is distinguished from all the other organised beings in the midst of which he is placed by the comprehensiveness of the conditions of his economy, he is also peculiar in the mode in which he is enabled to provide for them. His peculiarity consists not so much in the complexity of his corporeal frame, as in the character and sphere of his consciousness. The conscious principle, if the expression may be so applied, of the horse or dog, is influenced only by external circumstances ; the sphere of its activity is, so to speak, altogether external to itself ; impressible from without, and therefore, in some sort, conscious of surrounding objects, it is altogether

unconscious of itself. The so-called mental powers of the animal are capacities and faculties excited only by corresponding external objects, or by the recollection of these. Not endowed, therefore, with independent powers, its acts are acts predetermined for it, in the fundamental arrangement of its entire economy, with a precision and to an extent exactly commensurate with the conditions of its existence and welfare. The animal has consequently no field allotted to it for the exercise of judgment, and can therefore commit no error, nor be responsible for any act.

In our human economy, on the other hand, we are not only conscious of the material objects which surround us, but we have, in addition, a consciousness, even more vivid, of our conscious principle itself. We recognise in our economy, moreover, not only certain capacities and faculties, the proper ends, operations, and scope of which are directly predetermined and arranged, as in the lower animals, for certain essential requirements; but we are conscious, in addition, of beliefs, capacities, and faculties, the objects of which are indicated, and their operations conditioned and regulated, by the laws of the conscious principle itself. In virtue of the endowments of this, his higher principle, man is enabled to extend continuously his knowledge of the laws of external nature, and his influence over her. From the same source he derives his consciousness of the law of duty, and of that liberty of action with which it is associated: hence also, through free knowledge and moral liberty, the unassisted human reason acquires the conviction of a supreme Lawgiver.

You will now observe why it is that man is distinguished from the lower animals by the comprehensiveness of the conditions of his economy. In the case of the lower animal, the means by which the conditions of the welfare of its economy are secured and adhered to are provided in its instincts. Although man, again, has also had secured to him, through

his instincts, certain essential conditions of his economy, nevertheless the general conditions of his wellbeing, under the ever-varying circumstances in which he is placed, are—irrespective of revealed truth—only indirectly provided for him, through his self-conscious intelligence. His instincts, in common with his corporeal frame, constitute an organism, and so far the human constitution is similar to that of the lower animal ; but the organism in man is merely the instrument of his self-conscious intelligence, and it is this circumstance which entails upon him the comprehensiveness of the conditions of his welfare. He commences life less amply provided with instinctive securities than the lower animal. He must acquire the use even of his organs of sense, and of his limbs, by a self-conscious process of experiment. The knowledge of external objects, which is gradually accumulated, and the control over them which is acquired by the individual during his life, and by the species collectively, is the gradual result of a continuous struggle between his conscious principle and that material nature by which it is surrounded and penetrated ; and for this continuous effort his organism is the instrument. In like manner, the due performance of all his duties, personal and social—his duties to his Maker, his duties to his fellow-men—is, from the very constitution of his conscious intelligence, a life-long struggle between truth and error, fulfilment and non-fulfilment. These collective peculiarities of the self-conscious principle, as contrasted with the instinctive manifestations of the organism, constitute the proper personality of man, as distinguished from the mere individuality of the lower animal.

Such are the comprehensive conditions of the welfare of the human economy. Their extent depends upon the endowments of the human conscious principle. Now, as the most remarkable of these endowments are the capacity of discriminating, and the liberty of choice between truth and error—

between right and wrong—there exists a constant liability to disturbance. The disturbance is not so great, nor are its consequences so detrimental, in the progress of science as in the sphere of duty; for, as the acquisition of knowledge by intellectual effort is precisely conditioned by the laws of our consciousness itself, and the motives to the application of it to economical purposes sufficiently powerful, the obstacles to the progress of science are continuously diminishing. In the sphere of duty, again, the disturbing element—the tendency to select the wrong instead of the right—is in constant operation. It is not necessarily affected by the progress of science and its economic applications. On the contrary, the occasions for its disturbing action would appear to become even more numerous as so-called civilisation advances.

It is sufficient for the sequence of my argument that at this point I merely allude to that Dispensation which provides the aid necessary for man in the sphere of his duties and responsibilities—that Dispensation, the nature and application of which constitute the object and calling of another profession.

The number of injuries and diseases which occur in man is much greater than in any of the lower animals. The conditions of the welfare of the latter are strictly limited to the cosmical arrangements of their special areas of distribution, while their instinctive endowments determine precisely the amount of disturbance of health, or the amount of death, which occasional or periodic cosmical changes produce. So also injury and loss of life are necessary conditions of the general organic economy. For the life of a carnivorous animal involves the death of the animal on which it feeds, as the life of the herbivorous animal involves the death of the vegetable. Domesticated animals are liable to numerous diseases and special injuries; but these are due to their association with man, who entails upon them much suffering, from which

they would be saved if left to the guidance of their own instincts. As disease, then, is the result of a divergence from the conditions of health; as man is privileged, in virtue of his conscious intelligence, to provide for himself the conditions of health over the extended area of the globe, and under a never-ceasing variation of circumstances; but as he is at the same time liable, from the nature of his conscious intelligence, to diverge from those principles of truth which guide to the knowledge of the conditions of health, and to neglect that sense of duty which indicates the proper application of that knowledge when acquired, he becomes subjected to the necessary evil consequences. These consequences I need not enlarge upon. They involve all the disease and suffering which result from the neglect or infringement of duty to ourselves and to our fellow-men. They stand related to all the questions of personal and social ethics, and all the demands of public hygiene. Finally, they constitute the grounds of another general principle in the philosophy of medicine, which is, *that the greater liability of man to disease is intimately related to his higher conscious intelligence.*

How essential, then, gentlemen, must it be in your profession that you should possess a clear and comprehensive conception of all the arrangements by which human life is conditioned and modified! How vague and limited are our conceptions of these arrangements apt to be! We are apt to look for them in the dissecting-room and pathological theatre, and to forget that their most influential elements are beyond the reach of the knife, or the penetration of the microscope. Even when compelled to take into consideration the relations of the conscious intelligence to the bodily frame, we are apt to consider it as an intrusion into a department of inquiry which may adjoin, but which forms no part of our own. I venture to insist upon this topic, because by some it may be considered as entirely foreign to medical interest; and by

others as involving questions admitting only of metaphysical discussion. But the reciprocal influences of the conscious and material elements of the human constitution must be admitted as all-important conditions of health and disease, and the investigation of the laws of these two opposite influences demands only a rigid adherence to both of the distinct methods of inquiry respectively peculiar to psychical and to physical science. And, moreover, this is not the question as to whether the body is only a form of the mind, or the mind a product of the body. It is not the question as to whether the mind is merely deposited in the body, or whether the mind accumulates and arranges the different parts of its own habitation, and regulates and controls them during life. These are questions interesting in the history of philosophy, and involve metaphysical discussion properly so called; but they are questions having no immediate bearing on our topic, which includes an extended series of facts, intimately and immediately connected with the wellbeing of humanity.

Every decided advance in philosophy or science is coincident with the ingress of clearer conceptions of the object to be attained, and of the method of attaining it. Towards the acquisition, therefore, of a clearer conception of our subject, it is very important, not only that the distinctive characters of the conscious principle and of the material frame should be kept steadily in view; but also that the two perfectly distinct methods of investigating them should be rigorously adhered to. Now we find, in the present phase of our professional science, that although the rigid application of the precise methods of chemical and physical research to the investigation of the organic structures and actions has proved that the influence of chemical and physical force extends far beyond the limits formerly assigned to it in the living economy, nevertheless this has in no degree weakened the evidence of a co-existing element in organisation neither

chemical nor physical. For in proportion as the test-glass, the galvanometer, and the kymograph, transfer successive departments of organic science into the domains of chemistry and physics, so much the more remarkable do the characteristics of organic chemical action and of anatomical configuration become, and all the more striking and peculiar are the phenomena of consciousness felt to be.

The characteristic peculiarity of chemical action in the organism appears to consist in this, that certain of its products are such as are never met with in inorganic nature. It would appear as if chemical force in the organism were under the control of an influence which, while it confines that force in the greater part of its function to a special form of action, does not thereby render it less a chemical force than when it acts in inorganic nature.

In like manner, while the different forms in which physical force exhibits itself in the several domains of inorganic nature are exhibited in the corresponding domains of the living being, it nevertheless appears, in certain of its most important departments, to be confined by some influence to a manifestation of itself, such as it never exhibits beyond the limits of organisation.

As, however, some of the most striking features of organic form have now at last been reduced to geometrical characters, and subjected to mathematical analysis, there appears to be no ground left for the assumption that all organic forms and movements are not immediately or directly due to physical forces, or do not admit of being investigated and determined by the sole application of physico-mathematical methods.

If, then, gentlemen, I have exhibited correctly the present position of certain important departments of medical science, what are its future prospects? It will, in the first place, undoubtedly, as its several departments merge into the exact sciences, assume gradually a more precise character, and

demand from its cultivators, and from those who may desire to enter within its precincts, a much more thorough physico-mathematical training than has hitherto been considered necessary to the science or art of medicine.

In the second place, as every advance in chemico-physical truth is followed sooner or later by a corresponding application of it to the wants of humanity, so we may confidently look forward to a continuous increase in the number of chemico-physical appliances to the amelioration of human suffering, and to the prolongation of human life.

Again, as it must be admitted that the science of organisation, and more particularly the entire science of the human economy, necessarily involve the laws of the instinctive manifestations and of the conscious intelligence ; as, moreover, it is essential to every increase in the clearness of our conceptions of these laws that they should be investigated through the only medium which our human, and therefore limited faculties supply ; and as the advance of chemico-physical science into the domains of organisation has only had the effect of bringing the instinctive manifestations and the fundamental facts of conscious intelligence which are involved in organisation more strongly and distinctly into view, and of reserving them for the methods proper for their investigation, we may, I believe, confidently anticipate great progress in the psychological department of organic science.

As we have already seen that the peculiar liability of man to corporeal injury and to disease is directly related to the intellectual and moral departments of his constitution, we may confidently assume that the more careful study of these departments of the human constitution, in their relations to disease, will tend greatly to the amelioration of human suffering and to the longevity of the race. And here I would observe, that in as far as disease is mediately dependent on dereliction or neglect of personal duty, in so far also as it

depends on social dereliction and neglect of duty—in all these relations of disease, you, as physicians, are only indirectly interested. It would be a great mistake, however, were you to assume that you have fulfilled all the duties of your calling when you have treated the cases which come under your observation. Your science can alone supply information regarding the primary causes of prevailing disease, necessary for the selection of the proper public measures for its prevention. I need here only remind you how much has already been done, and is now doing, in this direction, and express my belief, that as the greatest boon which your profession has hitherto conferred on the community has been the prevention of disease, her future services in the same direction will not be less valuable.

Throughout this address I have insisted much on the intimate relation which exists between the conscious principle in man and his liability to disease ; and I may therefore here remind you how much the comfort of the patient, and the satisfactory progress of his cure, are dependent on the character and demeanour of the physician. If the psychical condition of your patient undoubtedly influences his corporeal state, it becomes an essential part of your duty to secure for yourselves that respect and confidence which are so readily accorded to your profession, and which tend so essentially to the welfare of those entrusted to its care. This character and this demeanour will be best secured by looking on your profession, not as a mere science, with its formal application, but as an extended series of duties, the nature and scope of which are indicated in the very nature of the profession itself.

In conclusion, permit me to say, that if a tendency produced by my own studies, and if what I hold to be the fundamental principles of the special science which I profess, have given a peculiar colouring to this address, or have

tempted me to allude to topics which might appear out of place, or might require more delicate handling than I can give them, my excuse is, that in the present crisis of this University, and in the fulfilment of the special duty which devolves upon me on the present occasion, I felt myself called upon to define explicitly, from my own point of view, the present positions and relations of medical science and of your profession.

For my colleagues and for myself, permit me also to state, that in dissolving the tie between us as teachers and pupils, we welcome you most sincerely as Graduates of this University, and members of our common profession.

IV.—THE PRESENT ASPECT OF MEDICINE.*

Ἰητρικὴ γάρ ἐστι πρόσθεσις καὶ ἀφαίρεσις.
Hippoc. ΠΕΡΙ ΝΟΣΩΝ.

Gentlemen—Had I acted in accordance with my own feelings, and with those arrangements which I have latterly found most conducive to my efficiency as a teacher and man of science, I should have gratefully but firmly declined the honour you have conferred on me by placing me in this Chair. I could not, however, forget that, among the aspirations of my earlier life, none were stronger than the desire of attaining an honourable position in the practical department of my profession; and that although the comprehensive study of the science to which I am devoted, and the duty of teaching it, now necessarily occupy and exhaust my time and energies, nevertheless I could not decline attempting at least to act in accordance with the wishes of a body of my professional brethren, for whom I have so warm a regard, and to whom I am so deeply indebted, as the members of this Society.

The periodic change of office-bearers in a society like this is not to be viewed merely as the necessary transference of official duties from one set of persons to another. On the contrary, office-bearers must, in addition, be assumed to represent, more or less comprehensively, the objects and purposes of the Society itself. But as every department of human knowledge is contemplated from a somewhat different

* This inaugural address was delivered from the President's Chair at the meeting of the Medico-Chirurgical Society of Edinburgh on the 5th January 1859.

point of view by different individual minds ;—moreover, as the advancement of science and of art is the result of effort and opinions apparently divergent as often as convergent in their effect, much benefit may be expected from the periodic review by different minds of any important subject or department of knowledge. I am therefore hopeful that, in undertaking my share of this periodic duty, and in attempting to review the present state of medicine, and to direct your attention to its future prospects, I may do so the more effectively that, although originally trained to the practice of our profession, I have now withdrawn from practice; for thus, with all my practical instincts unaltered, I view our profession from without as it were, with, I confess, ever-increasing interest, but entirely through the medium of those physiological sciences to which I am devoted, and under the guidance of those modes of thought which I may be permitted, without incurring the charge of pedantry, to uphold as the basis of all effective and comprehensive inquiry, and which, as the results of early education, I have ever thankfully cherished.

A few weeks ago a member of this Society, than whom the history of medicine records none who have been more successful in the suggestion and establishment of new methods for the relief of or recovery from disease, asked me what I thought would be the next great advance made in physic? In reference to what was thus asked of me, I believe you will agree with me when I assert that every decided advance made in the prolongation of the average duration of human life has been mediately or immediately the result of clear conceptions in reference to the conditions under which human life is maintained. There can be no doubt whatever that the average duration of human life has been much more extended by the preventive methods which the instinct of man and physiological science have induced

the public and the medical profession to adopt, than by any of the so-called methods of cure. Such preventive methods consist essentially in providing or supplying that condition, or those conditions, of health, and consequently of increased duration of life, which may happen to be deficient or absent. In like manner, all trustworthy methods of cure, usually so called, consist essentially in providing the conditions of local or general health in the individual—that is, in providing the conditions of recovery. It is with methods of prevention and of recovery, therefore, that our profession has to do. If we make use of the terms "cure" or "remedy," we do so in their fundamental and not in their vulgar sense; for we do not profess to perform the one or to provide the other in their vulgar sense. What we only undertake to provide are—*firstly*, the conditions of relief or alleviation of pain, so far as these have been discovered; *secondly*, the conditions of recovery, provided these conditions can be restored; and *thirdly*, the conditions of longevity, within the limits assigned to the life of man in the present phase of his existence.

It would be a curious, but certainly not an unprofitable inquiry, to trace throughout the history of medicine the influence which the ever-varying, but always more or less dominant, conception of disease as a real entity has had on physic; to track, step by step, the change that came over the original conception and purpose of the duties of the physician,—over the conception of that art which, according to Hippocrates, consists in addition and subtraction, or, in other words, in the restoration of that harmony in the conditions of health, the derangement of which constitutes the essence of disease. What if it should appear that a great part of the labour that has been bestowed on the investigation of disease, and in the search after cure, has consisted in fruitless attempts to detect the presence of specific entities, and of counteractive specifics for their control and eradication?

How much of the mass of medical literature that has accumulated during the latter half of the last and the first half of the present century must the future historian of our art record as the result of the unconscious influence of the mythical conception of disease and of cure, working under the guise of scientific research and inductive philosophy? When shall we, in medicine, consciously and utterly reject the dregs of the Manichean doctrine, and see clearly, and for a practical end, that the essence of disease is only the disturbance of the laws of health?

But it may be said, "If disease be merely a transgression of or disharmony in the conditions of health, then medicine as an art (the art of healing, or skill in the application of the remedies of disease) can have no real existence; it has been a dream all along, an unconscious and unintentional imposture. Pathology, the science of disease, alone constitutes physic; and the learned and candid physician, who is doing so much to increase our knowledge of that science, can only shrug his shoulders when called on to prescribe." In this objection lies a fallacy, by which our profession is not a little influenced in these times. It also exhibits a form of professional scepticism that naturally results from a change begun in our conceptions of disease, without a corresponding change in our conceptions of treatment. We are casting aside the idea of the specific entity of disease; but we have not to the same extent freed ourselves from the influence of the idea of specific cure. The fallacy may be expressed thus:—There is no such entity as disease; therefore there need be no attempt at treatment. Our professional duty is a necessary form, due to the prejudices of the public and to the natural desire of suffering humanity for sympathy and assistance.

This reactionary tendency at particular epochs, of which the reasoning just noticed is an example, is not peculiar to

medicine. It forces itself on the attention of the observant student in every department of history. It is seen to be an invariable feature in the progress of art, science, and philosophy. Moreover, it always induces, sooner or later, its own correction, and will do so in medicine. The more clearly and comprehensively we grasp the conception of disease as being merely a physiological state, so much the more firm and uniform will be our confidence in the efficacy of physiological means for restoring health, and our conviction that these means alone constitute the conditions of relief and recovery from disease. The most obstinate sceptic in the efficacy of our heterogeneous materia medica prescribes morphine, quinine, strychnine, belladonna, hyoscyamus, and chloroform, with the most implicit confidence in the production of the physiological effect proper to each of these substances. The firmest adherent of the expectant method of treatment does not scruple for a moment to provide for his patient all those conditions of atmosphere, temperature, sleep, nutriment, and consolation, the efficacy of which cannot be called in doubt.

Why is it, then, that while physiology is making rapid progress, and our knowledge of the physiological character of disease has already attained a tangible form, we are still wavering and undecided in the treatment of disease, and that we present, in reference to it, either a reserved formality or the opposite extremes of mystical credulity and absolute scepticism?

I believe you will agree with me in ascribing the state of feeling to which I have just alluded to the unconscious tendency to consider any given remedial agent or measure too much as acting on any given disease as a whole, instead of viewing it as acting invariably on one or more of those disharmonised conditions which, in fact, constitute the disease. For it must here be borne in mind that the recent

advance in physiology has not only corroborated the ancient doctrine of the interdependence of the different textures and organs on one another, as constituent parts of the organism, but has, in addition, brought prominently under view the independent characteristics, not of organs merely, but of textures, with their constituent elements and parts. As respects a given healthy or morbid process, we are now attaining to the power of distinguishing the respective independent actions of the blood (not of the blood viewed as a whole merely, but of its elements), of the capillary, of the nerve-filament, of the proper texture of the part; and again, not of that texture viewed as a whole, but of its nuclei, of its internuclear substance (or, if you prefer the term, intercellular substance), and of the independent territories themselves of that substance.

It thus appears that a healthy process consists of a number of interdependent actions, each of which, however, is so far independent that it admits of being separately examined and influenced. In like manner, one or more of these so-far independent actions admitting of being unduly influenced, some one or more morbid phases of the originally healthy process may be induced. But since the so-far independent constituent actions of the process admit of being individually examined and influenced in both healthy and morbid phases, an intelligible principle is thus supplied for our therapeutic interference. For no principle in physiology is more firmly established than this, that certain natural and artificial substances, when introduced into the living body, increase or diminish, promote or restrain, the so-far independent constituent actions of its healthy processes. Those substances do not influence any one process as a whole, but only one or more of the so-far independent constituent actions of that process. One of those substances may influence only the action of the ultimate nerve-filament;

another, only the action of the internuclear substance ; a third, only that of the nucleus. The knowledge we possess of what may be termed this microscopic action of foreign substances on the healthy and morbid processes is as yet limited ; but it is sufficiently precise to serve as an indication of the path that must be pursued in advancing the subject of therapeutics to its proper position as the ultimate or final department of our art. And we cannot doubt that the same beneficence which has subjected to the power of man those extended resources whence he is commanded to elaborate the means of his sustenance, enjoyments, and social advantages, has also placed within his reach a due proportion of means for recovery from disease. When these means are sought for, not by the rude and impulsive efforts which have too often characterised the history of remedy, but by the sure and cumulative, though apparently indirect and tedious method of science, we cannot doubt that a great advance will be made in physic.

An advance in physic, then, is not a mere advance in pathology that merely involves but does not educe the principles of treatment. It must, therefore, be the eduction of the principles and means of treatment from their present more or less complete state of occultation that will constitute a real advance in physic.

The question as to advance in physic, again, suggests the natural inquiry—What are the limits and conditions of this advance ? Correct conceptions on this subject are much to be desired, as calculated to produce that legitimate confidence on the part of the public, and that assiduity in the search for and application of the resources of our art, which its importance demands.

In the first place, it cannot be doubted, although generally almost entirely overlooked, that the first, and probably the most important question which the public may put to our

profession is this—Under what conditions can the health of individuals be preserved and developed, so that life may reach its maximum in the present state of society? This is the question of individual and public hygiene. It was the leading question in ancient physic; and it is one which, although much has been said and done regarding it in recent times, has not, it may be safely asserted, had that attention paid to it which its importance demands. We are too apt to postpone the answer to a question so comprehensive as this, and to devote our attention to individual cases of disease. We are apt to forget that the cases of disease which we treat might never have occurred had the previous question been solved, and that it is as much the duty of the physician to communicate the conditions on which disease may be prevented as those on which it may be recovered from. The importance of this question, its comprehensiveness, and at the same time its legitimate character, as within the limits of admitted inquiry and action, can only be appreciated by those who have studied that complex system of intimately connected conditions—moral, psychological, and physical—on which human life depends.

In the second place, it may be asked, What amount of recovery from disease is due to the advising or providing the necessary conditions of it by practitioners of our art? I may venture to suggest that a greater amount of recovery is due to treatment than the profession itself might be inclined to admit. It is quite true that little credit is assigned to the *vis medicatrix naturæ* in a successful case of stone. But, on the other hand, is there not frequently too little credit attached to the continuous attention required in securing the administration of the numerous apparently trifling but complex and necessary conditions of recovery in a case of continued fever? Without doubt it will be found that, in a more advanced form of practical medicine, a much more

extended system of means and arrangements will be provided for the supply of the numerous and apparently trivial conditions of recovery in the great majority of recoverable cases.

In the third place, while it must be admitted that the means at present available for the alleviation of suffering and for the prolongation of life in irrecoverable cases constitute a large proportion of that benefit which medical art confers on society, there appears to be, nevertheless, great room for the discovery and application of means of alleviation, and of methods of treatment applicable to such cases. I do not refer merely to such cases as, from their severity, render the sufferers entirely dependent on the care and services of others, but to those numerous cases of all kinds, in which, after what may be considered as recovery from the original attack, the health continues impaired, or there is a continuous tendency to relapse, or to consequent forms of illness. The economy of the organism in such cases is very different from what it was previous to the original attack. Its wellbeing and duration, so far as these are attainable, are dependent on different physiological conditions than before—so different, that they may involve a total change in the external relations of the individual. Hence, again, I have no doubt that the same efficacious treatment, by physiological means and appliances, of chronic and irrecoverable disease will constitute a prominent feature of a more advanced form of our art.

If I have, in my previous statements, given the correct interpretation of the present aspect of our professional science, it would appear that while, in the first place, the prolongation of life within its prescribed limits, the recovery from disease when that is possible, and the alleviation of bodily suffering, are each and all conditioned by ordinary physiological laws ; and that as, in the second place, that

amount of prolongation of life, recovery from disease, and alleviation of bodily suffering, which our art has heretofore effected, have been so by the empirical or conscious application of physiological means; so, in the third place, the present position of physiology presents a satisfactory prospect of attaining the possession of a greatly-increased number of means and appliances, suitable for the supply and control of the numerous conditions essential to the preservation of health and to the recovery from disease.

How essential, then, must it be in the practice of our profession to possess a clear and comprehensive conception of those natural arrangements by which human life is conditioned and modified! How vague and limited are our conceptions of these arrangements apt to be! We look for them in the dissecting-room and pathological theatre, and forget that their most influential elements lie beyond the reach of the knife or the penetration of the microscope. Even when compelled by circumstances to take into consideration the reciprocal influences of the conscious principle and the bodily frame, we are inclined to consider it as a necessary intrusion into another domain—a domain which may adjoin but does not form a part of our own. Nevertheless, within that adjoining domain processes are more or less continuously in operation, influenced by and influencing the corporeal actions. It is true that, from our human and therefore limited intellectual constitution, we are obliged to examine and investigate the processes of our bodily frame and of our conscious principle through separate media. Our human reason reaches, examines, and investigates the processes of our material frame through the medium of the senses, as it reaches, examines, and investigates the forms and movements of the heavenly bodies. That same human reason examines and investigates the processes and acts of our conscious principle through the medium of that principle itself, of

which, in fact, it is only to be considered as the formal expression. The results obtained through the medium of the senses are not in the slightest degree more certain or more trustworthy than those reached through the medium of the consciousness. They differ only in the mode in which they are attained and the objects to which they are directed; and this difference again is a necessary consequence of the limited constitution of the human intellect.

I have ventured to insist on this topic, because I am aware that by some it is considered as entirely foreign to physiological and medical interest, and by others as involving questions of doubtful propriety because admitting only of metaphysical discussion. But the reciprocal influence of mind and body is admitted by all, as constituting an important condition of health and disease; and the investigation of the laws of these reciprocal influences constitutes departments of inductive science, differing respectively only in the character of the medium through which the facts are reached. This is not the question as to whether the body is only a form of the mind, or the mind a product of the body. It is not the question as to whether the mind is deposited in the body at some one or other period of its development; or whether the mind is first produced, and then accumulates and arranges within its own form the different parts of its own habitation, and regulates and controls them during life. These are questions important in the history of philosophy, and involving metaphysical discussion properly so called. But they are questions that have no immediate bearing on our topic, which involves an extended series of facts intimately connected with the wellbeing of humanity.

Every decided advance in science or philosophy is coincident with the ingress of clearer conceptions of the object to be attained, and the mode of attaining it. In physiology, therefore, we see at present that although the steady and

unprejudiced application of the precise methods of chemical and physical research to the investigation of the organic structures and actions has shown that the influence of chemical and physical force extends far beyond the limits formerly assigned to them in the living economy, nevertheless this has in no degree affected the evidence of a co-existing non-chemical and non-physical element in organisation. In proportion as the test-glass, the galvanometer, and the kymograph have dragged into view the purely material character of the forces in action in the living organism, so much the more clearly and strikingly do the organic characteristics of the chemical constitution and of the anatomical configuration and connection of the parts in action stand forth ; and so much the more remarkable, because in deeper contrast, do the acts of consciousness become.

The characteristic peculiarity of chemical action in the living organism may be said to consist in this—that certain of its products are such as are never met with in inorganic matter. It would appear as if the so-called chemical force in the living organism were under the control of an unknown quantity, which, while it confines that force in the greater part of its functions to a special form of chemical action, does not thereby render it less a chemical force than when it acts in inorganic matter.

In like manner, while the so-called physical force, as manifested in its domains of statics, dynamics, hydrodynamics, pneumatics, optics, acoustics, thermatics, and electricity, presents itself, in the living body of one of the higher animals, in its most complex relations in the corresponding departments of its influence, it nevertheless appears in the latter, like the chemical force in the same circumstances, to be confined by the same unknown quantity to a manifestation of itself, such as it never exhibits in inorganic masses. While the configurations of the inorganic

masses in nature are referable to various modifications of the polyhedron and of the sphere, the configurations of the masses, and parts of vegetables and of animals, involve the complex relations of curves of double curvature. Without doubt that force, in virtue of which the shell of the nautilus derives its form, the cartilage of a human joint its curvature, and the movements of the human limbs their helical character, is purely physical, and of the same nature as that force in virtue of which the planets possess their individual forms, and revolve in their prescribed periods and curves. But while the heavenly bodies present merely the configuration of spheroids, and have their paths confined to bare sections, the configurations of the masses and parts of the animal body, as well as their movements, are, in presence of the unknown quantity, involved, moulded, and curved according to the law of the logarithmic spiral. The complexity of the statico-dynamical relations involved in forms and movements of this character is such that it would almost appear as if that mass of analytic means, accumulated by the industry of the mathematician but not yet made use of by the physicist, is laid up in store for the future anatomist and physiologist; and as if the highest example afforded to us of the complex but orderly and invariable exercise of chemical and physical force is in the construction and actions of that human body, in connection with that conscious principle, also possessing its own laws, but endowed with the mysterious privilege of free will.

It may now be asked—To what does all this argument tend? What bearing can it possibly have on the practical question as to the future progress of the art of medicine? as to the additional means to be expected of alleviating pain, diminishing disease, and lengthening the term of life? I shall not consider the argument out of place if you agree with me in the conclusion to which it leads, that we ought to

have in the two domains of what may be termed anatomical and psychological physiology, if invariably investigated through the medium and by the process peculiar to each, the same confident expectation of advance in scientific knowledge, and in the practical application of that knowledge, as we have in other departments of inductive science, and in their practical applications.

I at one time intended to illustrate at greater length some of the more prominent and important features in the recent progress of pathology and treatment, and to refer to what has been done in that direction by members of this society. I feel, however, that an attempt to do so at present would not only be doing injustice to the subject itself, but would occupy too much of your time. Reserving to myself, therefore, the privilege of communicating, at our ordinary meetings, some of the remarks which I had intended to embody in this address, permit me to conclude by expressing a hope that, if what I have now delivered to you exhibits a view too much influenced by individual habits of thought, it will be found to present at least the great features of the present aspect of medicine.

V.—ON THE PROGRESS OF ANATOMY.*

Although this is not the first occasion on which I have had to commence an Anatomical Course in this Theatre, it is the first on which I have been called on to do so in the winter session as Professor of Anatomy. I will therefore direct your attention very shortly to the peculiar circumstances in which we are placed at this time, when the science is making rapid progress, and when much is expected both of you and of me. I do not know how I can do this better than by taking a brief retrospect of the progress of anatomy during the one hundred and twenty years it has been taught in this University. Short, comparatively, as the period is which I intend to review, it would far exceed the limits of an introductory discourse to enter into details. I shall attain my object much better by pointing out to you the influences which have affected the progress of our science, the various aspects which it has presented at different periods, and the comparatively small number of men, who, among the multitude of labourers in the same field, must be considered as the types of the particular epoch in which one or more of them appeared.

When we consider the progress which society in general, or any of the arts or sciences have made, we at once perceive that that progress has not been steady and invariable, but by fits and starts, presenting periods of action and of reaction,

* This lecture, introductory to the author's first Systematic Course of Lectures on Anatomy, was delivered at the commencement of the winter session 1846. It has not previously been published.—Eds.

epochs of rapid development, and of comparative repose. Each successive period of advance differs both from the one which precedes and the one which follows. It invariably produces one or more men, who, although apparently the active agents in bringing about the development of the period, are in fact only the mouthpieces of the many who feel but cannot express, who almost lay hold of the idea, but cannot fashion it into a tangible form. Thus it is that almost every great discovery has been claimed by more than one individual; Harvey, Newton, and Charles Bell were not allowed to enjoy their reputations in quietness; and the astronomers of more than one country have been lately disputing for their share in the discovery of a new planet. Each successive epoch, differing in some essential particulars, becomes therefore a period of repose when considered in relation to its predecessor. The interests of the last age, although no longer presenting the same freshness and excitement which they did to our fathers, do yet settle down with us into steady acknowledged principles of action usefully curtailed of their exuberances; only to be the better fitted to support and protect the more recent ideas of our own age. Thus do we find at any one time two sets of men—those of the old and those of the new school—pitted too often, I am sorry to say, by most natural prejudices, against one another, always viewing the same subject from opposite points, and therefore declaring stoutly the error of their opponents without perceiving their own; never seeing that the opinions of the one side are only the complement of the opinions of the other, and that the truth must be in a certain middle course, the resultant of twc apparently opposing forces. Thus it is, gentlemen, that all advance is accompanied by opposition, every society presents two parties, progress is apparently the result of antagonism; from which at least we may learn this useful lesson—to listen charitably to those who are opposed to us in opinion, and

to examine our opponent's statements from his own point of view.

Such are a few of the more important principles by which all history is to be studied. Let us examine by means of them the short period in that of our own science which I have selected for consideration on this particular occasion. Towards the close of the seventeenth, and at the beginning, but more particularly during the second quarter of the eighteenth century, our science advanced principally in the direction of what is now called Descriptive Anatomy. This period was the epoch of Cowper, of Cheselden, of Albinus, but found its principal exponent in the French anatomist Winslow. With this mode of studying the human body a corresponding change in the art of surgery was produced. The operations of Cheselden were not empirical, but were founded on his anatomical knowledge; and had I time, or were it more directly in the line of my subject, I would willingly point out to you the effect which this more precise anatomical study had on the French and Dutch schools of surgery of the period we are now considering.

Conspicuous among the great names of this period is one in which we in this Theatre, and connected with this University, are more particularly interested—I allude to the first Monro.

After the Union, at the beginning of the last century, Edinburgh had begun to rise into a condition of security and prosperity, which the continued troubles of the Scotch nation had for so many centuries rendered impossible. The Corporation of Surgeons of that period—now the Royal College of Surgeons—ever zealous in the improvement of medicine in Edinburgh, had the credit of giving rise to the anatomical school of Edinburgh by establishing a professorship of anatomy to their own body; which appointment, although from circumstances, almost nominal, yet had the effect of bringing

about the formation of an anatomical school in the University, in the success of which all parties were equally zealous, and to which Dr. Monro was appointed. Dr. Monro possessed all those qualifications necessary for the position in which he found himself. Educated as an anatomist by his father, who was himself a surgeon and practitioner, he then dissected under Cheselden in London, and studied under Winslow and Albinus in Paris and Leyden, and therefore combined in himself all those peculiarities which characterised the anatomical epoch in which he lived and taught. The instructions and example of Cheselden and Boerhaave—the latter, although better known as a physician and chemist, yet at the same time a learned anatomist—excited in Monro those unceasing efforts which he ever afterwards made to improve the practice of our profession, by the correspondence he kept up with his numerous pupils and with other practitioners; by the papers which he published in the *Edinburgh Medical Essays*, and which led Haller to state, in reference to these essays, "Monrous ibi eminet;" and by the precise manner in which he taught anatomy to his class, always with a view to the practice of medicine. The effect produced in him by the peculiar tendency which I have already alluded to in the prelections of Winslow and Albinus, is evinced by the description which he published of the bones and nerves. Both works were speedily reprinted in several languages, and illustrated by engravings. They are both good examples of the accurate descriptions peculiar to the period; and the former is still one of the best works I can recommend to you in your studies of the human skeleton.

By his residence in Leyden he imbibed his fondness for making and collecting anatomical preparations—an art which was one of the characteristics of the epoch which immediately preceded his own. It took its rise in Holland. Swammerdam, and particularly Ruysch, invented and almost brought

it to perfection; and Monro must have learned from Albinus its application to the investigation of the exact course of the human blood-vessels.

I would willingly, gentlemen, had we time, enlarge on this part of my subject; I shall feel, however, that I have said enough if I have interested you in the memory of a former member of this University—a man, the truth, the simplicity, and earnestness of whose character are so much to be admired, and who contributed so largely to the advance of our science and profession. For I cannot conceive how any one can follow any pursuit who does not admire and strive to imitate those who have formerly excelled in it.

About the middle of the last century, we enter upon a period which may be said to terminate shortly after the beginning of the present. During this period descriptive anatomy continued to be prosecuted, but, with the exception of the treatise of Sabatier, no great systematic work was produced; the attention which continued to be devoted to it rather evinced itself by the number and value of engraved illustrations. To this class belong the *Icones Anatomicæ* of Haller—that universal genius, at once poet, botanist, anatomist, physiologist, and physician. The plates of Haller, from the truth and nature which they exhibit, so different from the artificial stiffness of those of Albinus, or of any former illustrator, with the exception of those of our own Cowper and Cheselden, are equalled only by the enormous learning which he brought to bear upon the subject. Amongst a number of other works of the same kind, I need only mention those of Vicq d'Azyr, Sandifort, and Caldani. This continued prosecution of descriptive anatomy was not, however, the characteristic feature of this period. This second epoch was characterised by the rise and systematic establishment of human physiology, that department of our science which is devoted to the force existing in the living healthy body, in

contradistinction to descriptive human anatomy, which treats only of the material structure of the frame. Just as we found the descriptive anatomy of the former epoch, although not entirely originating, yet systematised, in the work of Winslow, so in the period now under consideration do we find human physiology systematised, and to a certain extent originating, in the *Elementa Physiologiæ Corporis Humani* of Haller. But much as Haller did for physiology by his own continued researches and his great systematic work, there were other labourers in the field, whose exertions have produced a lasting influence on the science. Of these, the second Monro and his colleague Dr. Robert Whytt are conspicuous. They were both professors in this University—the former of anatomy, in which he succeeded his father ; the latter of the institutes of medicine. Dr. Monro *secundus*, by his continued researches and suggestions in the physiology of the nervous system, organs of the senses, absorbent vessels, action of muscles, showed an acuteness and far-sighted penetration which give his opinions and observations a place in all the researches on these subjects in the present day. Dr. Whytt, by his views in regard to vital and involuntary motions, and by his celebrated controversy with Haller, greatly influenced the physiology of the period. During this period, also, the labours of John and William Hunter in London added largely, and gave a great impulse to physiology. William Hunter, enthusiastically fond of practical anatomy, physiological experiments, and anatomical preparations, and devoted to teaching his favourite subject, a man of refined taste and conciliatory manners, great as he was, is not to be considered as the leader of his period. He was rather to be considered as the head of a school from which great men emanated. He was the first to discover, and in every respect to understand and appreciate his brother John. He educated Hewson, he fostered and brought forward Mathew Baillie. He may, in some measure, be considered as

having given the recent great impulse to all the three departments of our profession—pathological medicine through his nephew Baillie, surgery through his brother John, and obstetrics by his own individual efforts. Neither can John Hunter—a man who was considered by most of his professional brethren as a dreaming physiologist and a theorising surgeon—be looked upon as the type of this second epoch now under consideration. He was brought up in the dissecting-room, at the time when descriptive anatomy was chiefly studied. He was also an experimental physiologist throughout his whole career. But putting out of view his surgical works, his writings during his lifetime did not so much promote the advance of anatomy as of physiology, and great as they were, do not, considered merely in the period when they appeared, occupy so prominent a position as those of Haller. But to us at the present day, who can read them through the knowledge which his own labours have promoted, they possess a far deeper meaning than could be appreciated at the time. We can now perceive traces in all his writings of the great work he was silently engaged in, a work understood at the time only by a very few, and now brought to light through the invaluable exertions of Mr. Clift and Professor Owen, under the influence of the College of Surgeons in London.

It has been proved that he had made and noted down, in propositions of extraordinary beauty, not the anatomy of man alone, but that of the whole organic world, arranged so as to exhibit a knowledge far beyond what was dreamt of by any of his contemporaries.

I have already pointed out to you how the accurate anatomy of Winslow, Cheselden, and the first Monro, reacted on the art of surgery, and it is interesting to observe a corresponding reaction in the physiological tendency of the latter half of the century. In Edinburgh the era of the two Monros and Whytt was also the era of Cullen and Brown, and their

respective partizans, and of the influence exercised through them on physic. In London the physiology of John Hunter influenced surgery, and has made a still greater and more permanent impression on medicine. At the risk of becoming obnoxious to the charge of nationality, I cannot but observe here that the physiological bias of the second Monro, the peculiar character of the views of Whytt, Cullen, and Brown, and the physiological and pathological principles of John Hunter, all fellow-countrymen, in accordance with that tendency to abstract speculation which characterised a large section of the Scotch philosophers of the period, was destined to exercise on Continental medicine as great an influence as the Scotch school of philosophy and metaphysics, which took its rise early in this period, has exerted on those abroad.

And here, gentlemen, I must recall your attention to a name which I have already mentioned more than once, and which occupies so conspicuous a place in the anatomical records of this period. Under his father, the second Monro became an accurate descriptive anatomist. Attached at an early age to the practice of his profession, which he continued to prosecute for the greater part of his life, he proceeded to Berlin, where, under the first Meckel, he pursued his favourite subject. It was under Meckel that he prepared his essay, *De Venis Lymphaticis Valvulosis.* Already imbued by his father with a love of making anatomical preparations, he prepared at Berlin quicksilver injections of the tubes and lymphatics of the testes and spermatic duct, which still exist in our museum. He ever afterwards retained his early predilection for the study of the lymphatics, acquired great dexterity in injecting these vessels, and entered with much keenness into a controversy with the Hunters regarding the priority of their presumed discovery of the functions of these vessels, and with Hewson regarding the lymphatics of birds and fishes.

A few years after the commencement of the present

century new views opened up in our science, and it began to be prosecuted by different individuals, in different directions and with different objects. Just as we found, in passing from the first to the second epoch, that the results of the leading researches of the former passed on as modified but acknowledged principles of action into the latter, so, in passing from the second to the third epoch, both descriptive anatomy and physiology continued to advance. The systems of descriptive anatomy published during the present century are very numerous—as, for example, the works of Portal, J. F. Meckel, Bichat, Cloquet, Hildebrandt, Sömmering, and Blandin; but they are all modelled on that of Winslow. The engraved illustrations have also been numerous, and of these the plates of Walter, Scarpa, Weber, Tiedemann, and Barclay, may especially be mentioned. But the period now under review, extending to within ten years of the present date, is chiefly characterised by the rise and progress of three apparently distinct departments of anatomical science—general anatomy, surgical anatomy, and comparative anatomy. Not that these had not their respective cultivators, and made some progress, in former periods of the history of our science, but it is only in the nineteenth century that they have become systematised and characteristic.

General anatomy—by which term we understand the systematic structure, physiological properties, and pathological phenomena met with in the different textures of which all the organs or parts of the body are composed, each texture considered by itself—may be traced as a germ in the school of William Hunter, was almost expressed in the physiology of Haller, gives a complexion to the morbid anatomy of Baillie, and suddenly appeared in its present advanced condition through the genius and works of Bichat. With the works of Bichat on physiology and general anatomy you must in due time make yourselves acquainted; for until you are thoroughly

imbued with the spirit of these works, you cannot fully understand the bearings of human anatomy on the higher departments of medicine. Beclard, a pupil and enthusiastic admirer of his great master Bichat, produced an excellent work on *general anatomy* in the same spirit, of which there is an English translation by Dr. Knox. J. F. Meckel produced in Germany, where this department of the science had been already in advance, his General and Morbid Anatomy, which is also translated into our language. It is to general anatomy that we owe the present improved state of pathological medicine, and these two subjects must ever advance hand in hand, and should any of you be inclined to give ear to the statement so often made, that anatomy is necessary to the surgeon, but not to the physician, recollect that the illustrious founder of that general anatomy to which we owe the present advance in physic, was a profound descriptive anatomist, and wrote one of the most complete and elegant systems we possess on the subject.

Surgical anatomy may be defined to be the dissection and description of the regions of the human body in which surgical operations may be performed, or injuries and surgical diseases may occur, in such a manner as to become acquainted with the exact relative positions of all the parts,—skin, fat, muscles, nerves, and vessels,—with a view to diagnosis and operation. Like general anatomy its promotion may be traced in the works of various authors, previous to the present century; but it is only during this century that it has become a subject of systematic study. It first assumed this form in the celebrated work of the late Mr. Allan Burns, *On the Surgical Anatomy of the Head and Neck*, and we can only regret that the premature death of this excellent lecturer, surgeon, and anatomist, brought on by his devotion to science, should have deprived us of the remainder of a work which, as far as it goes, has not even been approached by any of his

numerous followers. A host of writers on surgical anatomy have since appeared, most of them belonging to the French school. Their writings are characterised by the clear systematic arrangement and luminous description which are peculiar to the genius of the French people and language. But this method and completeness is at once their peculiarity and their fault, they induce fatigue without proportional instruction, and I appeal to the experience of those of you who have already acquired some knowledge of this department, whether you have derived the same useful information from the laboured works of Velpeau and Blandin, as from the plain common sense and discriminating accuracy of Allan Burns.

Since the rise of surgical anatomy a number of manuals have appeared, and been extensively used, being arranged not systematically, but in the order of dissection. To them your attention will be more particularly directed in the course of demonstration and in the dissecting room.

The department of our science which has been most extensively developed in the period now under consideration, is comparative anatomy—and with this the name of Cuvier will at once suggest itself to you. Much, however, as I revere that name, and fully as I appreciate the extent of the discoveries in comparative anatomy with which it is associated, I am bound to add the expression of my belief to that of most competent judges, that the French anatomist must yield to John Hunter, not only the priority of discovery, but the greater part of what was discovered ; and even the very arrangement of the system. But it is not so much for these reasons that I would consider Mr. Hunter as in advance of Cuvier. The discoveries of Cuvier in fossil anatomy have given an impulse to the fashionable science of geology, and a consequent brilliancy to his reputation, incommensurate with the absolute difficulty of the researches. That Mr. Hunter was fully alive to the importance, and capable of entering into

this line of research, his writings and collections fully testify. But it was in the application of his vast knowledge of comparative anatomy to physiology and pathology, and the consequent advancement of the less brilliant but more useful science of medicine, that he so far outstripped his rival.

Both were alike well acquainted with the structure of the animal kingdom, from the monads to the monkeys. This knowledge Cuvier applied to natural history, and expanded it in zoological arrangements and geological research. Hunter, again, was Cuvier's superior in vegetable anatomy. He was what Cuvier never professed to be—an accurate human anatomist; and he saw what Cuvier could not perceive—the identity of the laws of healthy and morbid structure and function. When the celebrated Rudolphi, himself, like Hunter at once a zoologist, a comparative anatomist, a human anatomist, and pathologist, was conversing on one occasion with Cuvier about a certain pathologico-anatomical specimen, the latter replied —"Mais ce n'est qu' accidentel," an expression which proves how far inferior he was to Hunter in his perceptions of the bearing of his science.

Thus, it was his knowledge of pathology which gave Hunter his superiority. He employed his extended knowledge of comparative anatomy to break down the obstacles in the way of advance of pathology and medicine; and using the power he thus possessed, he reversed the process, employing his pathological principles to explain the healthy organic phenomena which he observed in the animal series.

Cuvier could push forward only in one direction, Hunter could advance on all sides. The one conducted his labours amongst a people ever ready and proud to facilitate the progress of their men of genius, and was supplied with every opportunity of research by a patron as ready and more able to assist him than Alexander was to promote the studies of Aristotle, Cuvier's own prototype in natural science; Hunter,

again, pursued his subject in a capital where success in business, rank, or property, are surer passports than literary eminence or scientific reputation. Harassed by a laborious practice, which alone supplied the means of prosecuting his researches, without the sympathy of the public, and with few professional friends, he did all by his own efforts, and left a museum of comparative anatomy superior to that of Cuvier, and a surgical reputation greater than any before or since.

During this period the progress in the Edinburgh Anatomical School partoök of the varied characters to which I have alluded. My own immediate predecessor in this chair, from his early acquaintance with Dr. Baillie and his school, acquired the prevailing taste for general and morbid anatomy which showed itself in his Morbid Anatomy of the Stomach and Gullet, and of the Brain. The former, especially from the learning and sound discrimination which it exhibits, has become a standard work in the literature of our profession. His intercourse with Mr. Allan Burns, and the influence of the period, had early directed his attention to various departments of surgical anatomy, as evinced by his writings and illustrations of the male pelvis, hernia, etc., and thus conduced in no small degree to develope the bold and successful operative surgery of the Edinburgh School.

I cannot conclude what I have said regarding the Anatomical School of this University, prior to the period we are now entering upon, without alluding, more shortly than I could have wished, to two names inseparably connected with its former history, Mr. Innes and Mr. Fyfe. The former, well known as the author of a work on the muscles, was educated as an anatomist by the second Monro, and long assisted him in the duties of the chair. Mr. Fyfe devoted himself to anatomy, when advanced in life, and became, under the same master, one of the most accomplished practical anatomists of his day. He was not only a most assiduous and dexterous

dissector of the human body, but was also well versed in comparative anatomy, as is shown by his published systems of Human and Comparative Anatomy. His favourite employment was injecting, particularly the absorbents, with quicksilver, in which he rivalled his master, and whom he greatly assisted in his researches on the subject. Mr. Fyfe was, in addition, a man of amiable and obliging disposition, and the pleasure which he took, when surrounded by a numerous band of students, in demonstrating the parts he was at work upon, is still remembered by many members of our profession who were students of the University at the time. He was also a man of most laborious habits, for being equally dexterous in the use of the scalpel, pencil, and graver, he drew and engraved with his own hands almost all the illustrations of his own and Dr. Monro's works.

I cannot leave the consideration of this period in the history of the Anatomical School of Edinburgh, without directing your attention to another anatomist who exerted a great influence on our profession by his writings and prelections. There are few anatomical teachers who have educated a greater number of members of our profession, who exercised a greater influence on their success in life, or gained a more warm and permanent respect for his memory, than the late Dr. Barclay. A profound human anatomist, in the highest sense of the term, he was also well versed in comparative anatomy; and although not himself distinguished by dexterity, nor ever engaged in the practice of our profession, nevertheless, the honesty and sincerity of his character, his enthusiasm in the teaching of his favourite science, the energy and success with which he encouraged actual dissection by the student, and the extent to which he promoted the interests and assisted the talents of his pupils, rendered him a most successful and popular teacher. Like every true anatomist, he was fond of anatomical preparations, and left to

the College of Surgeons the collection you may now see in their museum. Numerous as were the physicians and surgeons who studied under Dr. Barclay, he had also pupils who have distinguished themselves as comparative anatomists. Professor Owen, the worthy successor of Cuvier in the field of comparative anatomy and palæontology, and deeply deserving of our regard for the energy with which he has brought into view the hidden treasures of the museum of John Hunter, as well as Dr. Grant, of University College, were both his pupils, and doubtless were incited and encouraged by the kindred tastes and enthusiasm of their teacher.

Such were the directions in which anatomy advanced during the first thirty years of the present century. At the termination of this period we enter on the present times, which are not yet sufficiently advanced to enable us to see by what character they will ultimately be distinguished. One feature, indeed, which had begun to show itself in the last period has become very prominent in the present.

Our science has become cut up into numerous departments, studied by different individuals, who in general care little, and know less, of any department of the subject but the one of their own choice. Müller, Retzius, Eschricht, Hyrtl, Henle, Schwann, Vrolik, and others, still grasp the science in its totality, as was done by Haller, Hunter, and the Meckels; but in general the title of anatomist in the present day does not indicate this extent of knowledge.

He may be merely a comparative anatomist, or only a human anatomist; his knowledge may extend no further than the relation of parts in surgical regions, or the general structure of the viscera; or, still worse, his knowledge may consist of that heterogeneous kind—facts grouped together, not by the harmonious laws of nature, but by the circumstance of their being observed by means of the microscope. You will at once perceive that such a one-sided knowledge as this can possess

no vivifying principle. It cannot be productive. It never can be effectually employed in advancing the boundaries of the science, in applying it legitimately to medicine, or in elucidating its true principles to those who are learning. Here, gentlemen, lie the difficulties you will meet with in your anatomical studies. It is my duty to guide you past them, and to assist you in acquiring such a general, accurate, and well-balanced knowledge of the subject as shall fit you for the important duties you are afterwards to undertake. To see how this is to be done, let us examine briefly the direction our science has taken during the last ten or fifteen years.

The beautiful observations of Harvey and Malpighi on the formation of the chick *in ovo*, and the remarkable microscopic researches of Hooke and Leeuwenhoeck on the intimate structure of the textures and minute parts of plants and animals, much as they excited attention at the time, were almost forgotten, and the subject laid aside, principally on account of the imperfect glasses of the period. It was one of those attempts to advance a science in a direction for which it was not fully prepared, and belongs to a class of events which may be traced as well in the general history of nations as in the progress of the various departments of human knowledge. The more precise application by Mr. Lister of the different refracting powers of crown and flint glass, to correct the chromatic aberration of the compound microscope, again enabled anatomists to employ the instrument. About this time Von Baer and Purkinje, two German anatomists, began to use the microscope extensively—the former on the then neglected researches of Harvey and Malpighi, the latter on those of Hooke and Leeuwenhoeck.

Von Baer, followed by Rathke, Huschke, and a number of other German anatomists, speedily amassed a series of facts and principles, which now form an extensive department of our science—"the Anatomy of the gradual formation of the

embryos of all animals and plants." The exclusive cultivation of this department of the subject has within the last few years fortunately become amalgamated with the general science, and has given place to a much more general cultivation of an apparently more easy and therefore more attractive pursuit, originating in the researches of Johannes Müller, Henle, and Schwann, in co-operation with the vegetable anatomists —the intimate structure of the different textures and fluids, as revealed by the microscope and by chemical re-agents. The appellation Histology has been applied by the Germans to this subject, and there is no reason why the term should not be transplanted into our British nomenclature as well as others for which our language has not equivalent expressions. But I must warn you, for there is absolute danger in its use, against the term physiological anatomy now becoming fashionable. There is nothing, I can assure you, gentlemen, which has more retarded science and philosophy, and the kindred subjects on which human reason has been employed, than the introduction of terms with conventional meanings. Men come at last to defend the terms, as if they were the truth, and to mistake an artificial shadow for the substance required. The general advance has been retarded by partial and trifling skirmishing in the rear, instead of being pressed forward by an actual attack on the enemy itself. Is the intimate anatomy of the textures the only department of our science related to physiology? Is the anatomy of masses not as strictly physiological as the structure of atoms? And is it not at least injudicious in those who may be able fully to appreciate the value of their own terms to run the risk of leading others astray?

And here, gentlemen, I must be allowed to add a few words, first, in explanation of an apparent harshness which, I suspect, may have crept into my observations on the pursuit of anatomy by means of the microscope, partly to warn you against the dangers which I dread. It would be strange if I,

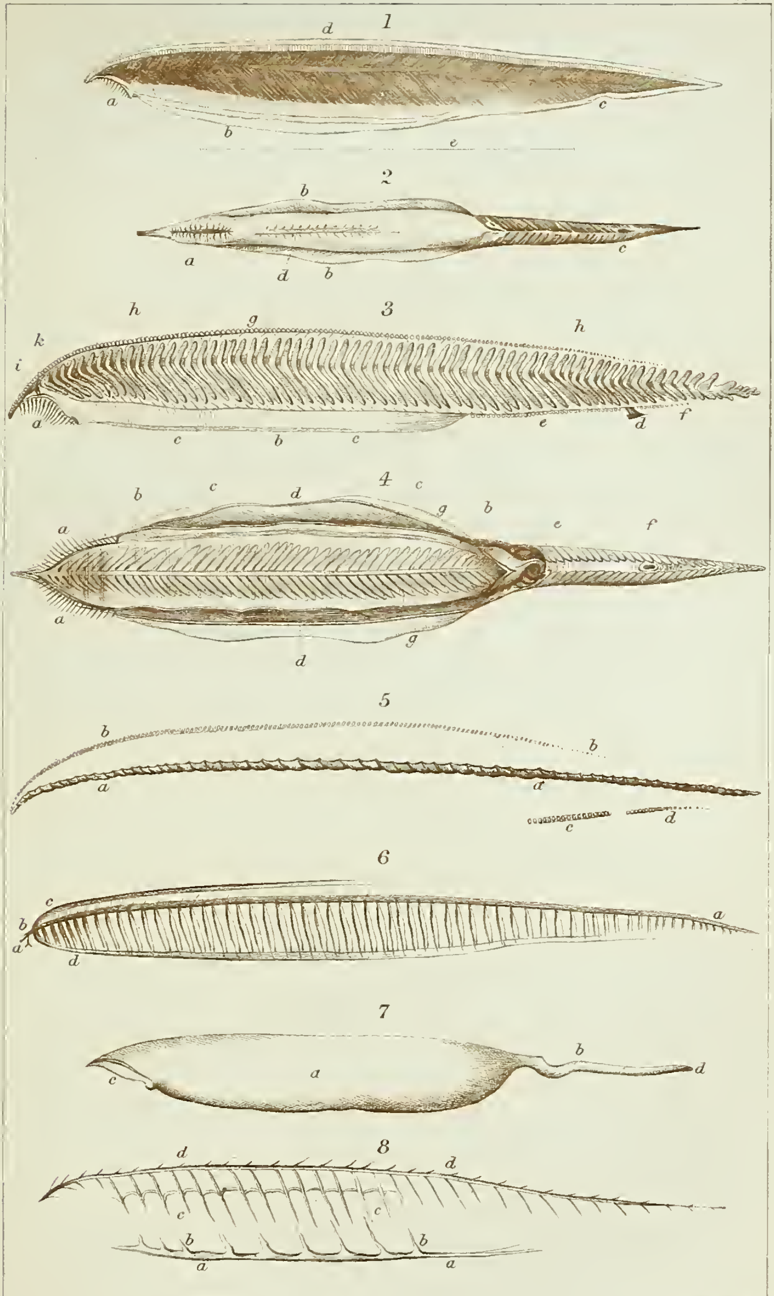
who have derived both pleasure and instruction from the use of the microscope, and who have had it in my hands almost daily since the commencement of my anatomical studies sixteen years ago, should entertain or promote any prejudice against that instrument. It is against the abuse, not the use, of it which I warn you. I beg of you not to employ it, or be induced by any one to do so, until you have to a certain extent mastered the details of descriptive human anatomy. That is the grammar of our science—the modeller of our anatomical ideas. It is by the study of it that we acquire the habit of thinking as anatomists, and drawing as anatomists. As soon would the astronomer place the telescope in the hands of his pupil, and request him to interpret the sinuous lines by which the orbits of the planets are projected on the apparent surface of the hollow sphere, before he has acquired steady ideas of astronomical forms and motions by preparatory studies, as would the judicious teacher of anatomy suggest the examination of objects by the microscope before strict anatomical ideas of form and relation had been acquired by the study of the bones, muscles, and blood-vessels. The child at birth does not, as you are aware, see things as they really are in space; the full use of his eyes he only gains after a series of instinctive experiments made by means of his other senses. It is thus that he comes at last to use, without conscious effort, organs which in themselves are no mere physical instruments. Now, the telescope and the microscope are additional eyes, and before they can be aright employed on the objects with which the astronomer and anatomist have to do, a supplementary education must be submitted to (an education the more irksome that the other senses cannot be employed to interpret the revelations of the new instrument) in order that the minute structures on the one hand and the heavenly bodies on the other may be correctly examined. The only mode of procedure is, in the one case, to form astronomical ideas

by the study of geometry and the result of former research ; in the latter, to reason from the forms and relations of the anatomy of large masses to the forms and relations indicated by microscopical appearances.

You will now be prepared, gentlemen, in some measure to comprehend the principles which I shall inculcate for your guidance. From among the innumerable facts within our reach I shall select and group together those which best illustrate the grand laws of the science, and which, in the hands of modern anatomists, have afforded such brilliant results. In this manner, I trust I shall be enabled to accomplish what I have long felt to be necessary in the present day, and especially in this country—a course of anatomical instruction, in which, without losing sight for one moment of the paramount importance of human anatomy, the laws of organic structure shall be evolved, so as to afford, as completely as possible, a view of that wide range of anatomical knowledge which is so essential to the advancement of scientific medicine.

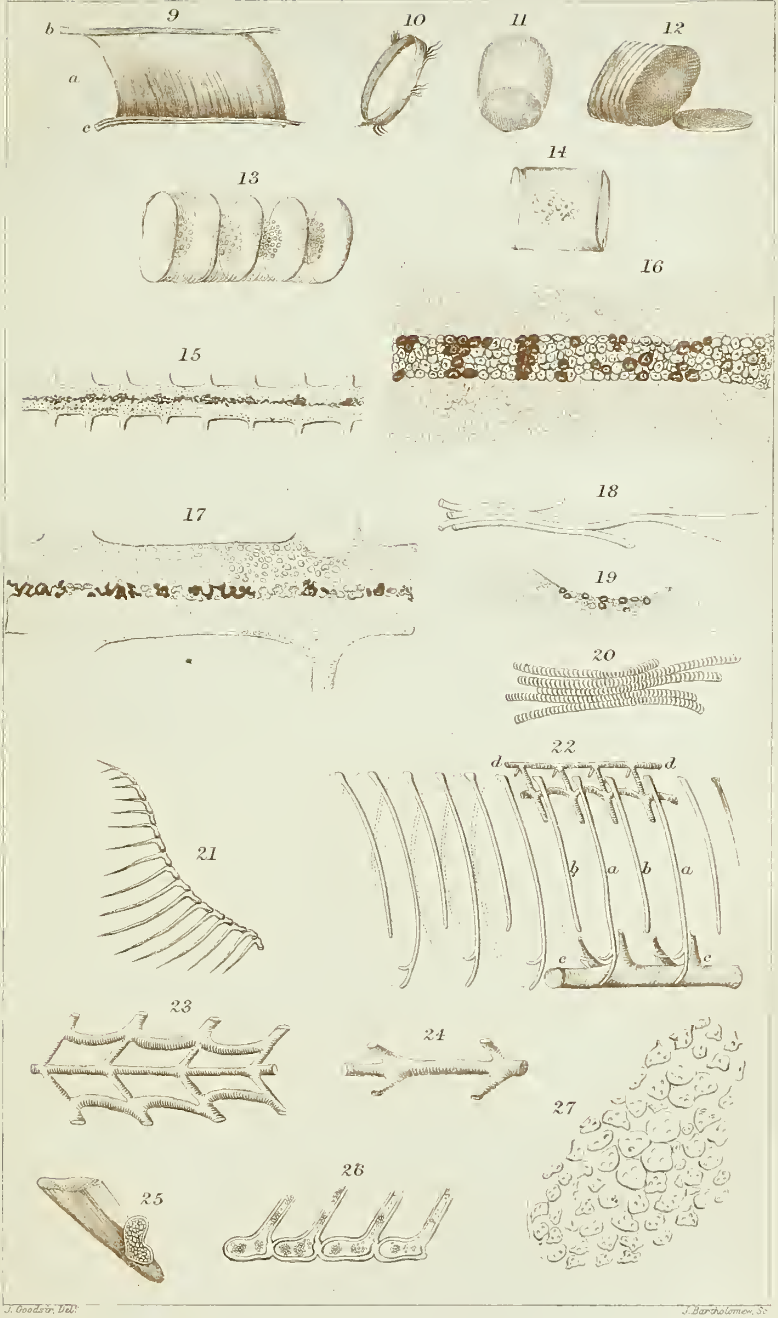
DIVISION II.

COMPARATIVE ANATOMY.



J. Goodsir Del.^t

J. Bartholomew Sc.



J. Goodsir, Del. J. Bartholomew, Sc.

DIVISION II.

VI.—ON THE ANATOMY OF AMPHIOXUS LANCEOLATUS.*—Plate I. II.

The genus *Amphioxus* was instituted by Mr. Yarrell for the reception of a singular little animal which he received from Mr. Couch. The characters of this genus, as given in the History of British Fishes,† are, "body compressed, the surface without scales, both ends pointed, a single dorsal fin extending the whole length of the back; no pectoral, ventral, anal, or caudal fins; mouth on the under part of the head, narrow, elongated, each lateral margin furnished with a row of slender filaments."

My attention was particularly directed to Mr. Yarrell's description of the Lancelet, by an announcement by my friend Mr. Forbes, at the Newcastle Meeting of the British Association, of the capture of two specimens on the Manx coast. With his characteristic liberality, that gentleman has put these two specimens into my hands, with a request that I would employ them for the purpose of drawing up a detailed account of the animal.

Unwilling to mutilate both, I have confined my dissections to one of the individuals, and have been fortunate enough to detect its leading anatomical peculiarities, to verify most of the observations of the anatomists who have preceded me in

* Read before the Royal Society of Edinburgh May 3, 1841.

† Yarrell's *History of British Fishes*, vol. ii. page 468.

the investigation, and to correct what appeared to me to have been errors in their observations. To complete the history of the Lancelet, however, an examination of it when alive in sea-water must be undertaken. In this way only, can certain points in its structure and actions be explained, and light be thrown on the economy of one of the most anomalous of the vertebrated animals.

The first notice which we have of the Lancelet is in the Spicilegia Zoologica of Pallas,* who received his specimens from the coast of Cornwall. Although he observed its ichthyic characters, he allowed himself to be misled by its other peculiarities, and particularly by the membranous folds of the abdomen. He described it well, but placed it in the genus *Limax*, under the designation *Limax lanceolatus*.

Professor Jameson has directed my attention to the first volume of Stewart's *Elements of Natural History*,† in which the Lancelet is described as a *Limax* with the specific designation *lanceolaris*. Mr. Stewart's description is evidently an abstract from that of Pallas, to whom he refers. He had, however, a right appreciation of the essential characters, as he states that the animal is "hardly a Limax."

It is to Mr. Yarrell, however, in his most valuable work on British Fishes, that we are indebted for the first detailed account of this animal. He recognised in his solitary specimen, the *Limax lanceolatus* of Pallas. In his description, which is in other respects most correct, he has omitted the lateral membranous folds of the abdomen, so well observed and embodied in the description of Pallas. Mr. Yarrell observed the vertebral column, the ichthyic lateral muscles, dorsal fin, intestines, and ovaries, and transferred the animal, therefore, to the Vertebrata. He placed it in the family Petromyzidæ, near the cyclostomous fishes, as he considered the fringed

* Pallas, *Spic. Zool.* x. p. 19, t. i. Fig. 11.

† Stewart's *Elements of Natural History*, 2d ed. vol. i. p. 386.

mouth, the armed lingual bone, the absence of eyes, and the want of pectoral and ventral fins, to be structural characters sufficient to connect it with the Lamprey and Myxine. For its reception he constituted a new genus, Amphioxus, and described the species under the designation *lanceolatus*, looking upon it as the lowest in organisation in the class of fishes.*

Mr. Couch, the indefatigable ichthyologist of Polperro, who supplied Mr. Yarrell with his specimen, published in the Magazine of Natural History, July 1838, a short paper, in which he gave some additional details of structure observed before the animal had been immersed in spirits. He considered it to be a fish with sixty vertebræ. He observed the anal fin, which had escaped Mr. Yarrell in the preserved specimen; he also described what he considered an anomalous kind of fin rays, in the form of transverse bows or arches, the curve forming the support of the fin, the pillars probably resting on transverse spinous processes of the vertebræ. He observed that these peculiar rays did not extend to the caudal portion of either the dorsal or anal fins. In his second specimen, on which the observations of structure were made, he could detect none of the ova which were so conspicuous in the first.

I was not aware till I had almost finished my examination of the Lancelet, that anything further had been published on the subject. A few weeks ago, however, I observed in the proceedings of the Berlin Academy for 1839, an abstract of a paper on Amphioxus lanceolatus by Professor Müller. From this abstract it appears that Professor Retzius of Stockholm has written a short memoir on the subject, in which he has announced the fact, observed by himself and Professor Sandevall, that the chorda dorsalis does not pass into a cranium, but terminates at a point behind it. Professor

* Yarrell's *British Fishes*, loc. cit.

† Bericht über die zur Bekann tmachung geeigneten Verhandlungen der Konigl. Preuss. Akademie der Wissenschaften zu Berlin. Nov. 1839, p. 197.

Retzius describes the spinal marrow as terminating considerably behind the anterior extremity of the chorda dorsalis, in a brain exhibiting scarcely any dilatation. He perceived a dark point which he supposed might be the rudiment of an eye, but he could observe no cerebral nerves. He saw numerous ribs, but no branchial clefts, and described a large opening at the posterior extremity of the gill-cavity, which he supposed to be a branchial opening similar to those in the myxine.

Müller's own observations were made upon Mr. Yarrell's specimen, and also upon two sent to him by Retzius. He verified Retzius's and Sandevall's account of the chorda dorsalis, on the sheath of which he perceived circular fibres. The oral filaments he described as consisting of central and tegumentary portions. The black spot or rudiment of an eye he could not detect. He observed the general structure of the branchial cavity, ribs, and vessels, but did not determine the existence of the branchial aperture described by Retzius. He states that the intestine terminates anteriorly in a cul-de-sac, a little behind which the branchial cavity opens into it on the left side. He supposed that some glandular streaks on the wall of the cul-de-sac of the intestine represented the liver, and considered a row of glandular masses on each side, consisting of cells containing dusky oval bodies as the ovaries. After some remarks on the structure of the muscles and skin of the Lancelet, Professor Müller states the necessity for further observations to ascertain the details of its structure.

The only specimens of the Lancelet, then, which have been examined are Pallas's specimen, Mr. Couch's two specimens, one of which is in the possession of Mr. Yarrell, the specimens examined by Retzius, Sandevall, and Müller, and the two in my own collection. Two specimens, I believe, exist in the Museum of the Zoological Society of London.*

* *Magazine of Natural History*, July 1838.

Having now stated what has already been done in the anatomy of this remarkable animal, I shall proceed to describe in detail the structure of the specimen I have depicted, reserving for the concluding part any general observations I may have to make on its structure and zoological character.

The dimensions and weight of the specimen of Amphioxus which has afforded the materials for this paper, are, length two inches; depth, a little before the middle, two lines; weight eight grains. The other specimen in my possession is half-an-inch shorter, and not so favourable for examination. They were dredged up by Mr. Forbes from a sandbank, in deep water, on the east coast of the Isle of Man, were extremely active, and resembled, on superficial inspection, small sand-eels. On each side of the abdomen are two longitudinal membranous folds, and behind them an anal fin, omitted in Mr. Yarrell's description. The folds commence, minute, on each side of the hyoid apparatus, pass back on the sides of the abdomen, increasing in breadth till they are as broad as one-fifth of the depth of the animal; they then diminish and terminate at the point where the lateral muscles approach on each side of the intestine, that is, at the junction of the middle and posterior thirds of the animal.

The anal fin is a fold of integument, which, commencing at the point where the abdominal folds terminate, is continued to the anus, where it is interrupted, but reappearing behind it, and becoming broader, passes on to be continuous with the dorsal fin at the extremity of the tail. The existence of a median fin in front of the anus is, as has been observed by Müller, very remarkable; but it is in exact accordance with a fact mentioned to me by Professor Agassiz, that in certain fresh-water fishes, the development of which he had watched, a fin of this kind, with rays, exists for a short period of their embryonic existence, and then disappears.

Anatomical Description of the Amphioxus.

Osseous System.

Neuro-skeleton.—The osseous system, properly so called, consists of a "chorda dorsalis" tapering at both ends, without the vestige of a cranium, and of a dorsal and ventral series of cells, the germs of superior and inferior interspinous bones and fin-rays. The "chorda dorsalis" consists of sixty to seventy vertebræ, the divisions between which are indicated by slight bulgings, and lines passing obliquely from above downwards on the sides of the column. In this way a separation into individual vertebræ is rather indicated than proved to exist; for although the column has certainly a tendency to divide at the points above mentioned, yet that division is rather artificial than natural. There is no difficulty in ascertaining above sixty divisions, those at each end above the number stated run so much into one another that no correct result can be obtained.

The chorda dorsalis is formed externally of a fibrous sheath, and internally of an immense number of laminæ, each of the size and shape of a section of the column at the place where it is situated. When any portion of the column is removed, these plates may be pushed out from the tubular sheath, like a pile of coins. They have no great adhesion to one another, are of the consistence of parchment, and appear like flattened bladders, as if formed of two tough fibrous membranes pressed together.

As the fibres of the sheath are principally circular, provision is made for longitudinal strains on the column by the addition of a superior and inferior vertebral ligament, as strong cords stretching along its dorsal and ventral aspects. The superior ligament lies immediately under the spinal cord, and may be recognised as a very tough filament, when the column is torn asunder, or some of the vertebræ removed.

The inferior ligament may be raised from the inferior surface of the column in the form of a tough ribbon. From the sides of the column aponeurotic laminæ pass off to form septa of attachment between the muscular bundles; and along the mesial plane above the column, a similar lamina separates the superior bundles of each side, and by splitting below and running into the sides of the column, forms a fibrous canal for the spinal cord. Foramina exist all along the sides of this canal for the passage of the nerves. A similar septum is situated along the inferior part of the column, from the part where the inferior muscular bundles unite at the anus, to the extremity of the tail. Along the superior edge of the aponeurotic septum, between the dorsal muscular bundles, and stretching from the anterior point of the vertebral column to a point beyond the anus, and half embedded between the superior extremities of the muscles, is a series of closed cells of a flattened cylindrical form, adhering firmly to one another by their bases, so as to present the appearance of a tube flattened on the sides with septa at regular distances. Each of these cells is full of a transparent fluid, in the centre of which is an irregular mass of semi-opaque globules, apparently cells. This series of cylindrical sacs consists of the rudiments of interspinous bones, and probably of fin rays, and is attached below to the fibrous intermuscular septa; half covered on each side by the lateral muscles, and enclosed above by the tegumentary fold which constitutes the dorsal fin.

A similar series of cells, with the same relations, is situated on the ventral surface of the body, and stretches from the spot where the abdominal folds terminate, to a point nearly opposite the termination of the dorsal series.

Splanchno-skeleton.—The splanchno-skeleton consists of a hyoid apparatus and a series of branchial ribs, seventy or eighty on each side. This division of the skeleton will be described along with the respiratory apparatus, with which it is intimately connected.

Nervous System.

The spinal cord is situated on the upper surface of the chorda dorsalis, enclosed in the canal formed in the manner above described. When the whole length of this canal is displayed by removing the muscles, and then carefully opened, the spinal cord is seen lying in the interior, with nerves passing out from it on each side. It stretches along the whole length of the spine, is acuminated at both ends, and exhibits not the slightest trace of cerebral development. In its middle third, where it is most developed, it has the form of a ribbon, the thickness of which is about one-fourth or one-fifth of its breadth ; and along this portion, also, it presents on its upper surface a broad, but shallow groove. The other two-thirds of the cord are not so flat, and are not grooved above, are smaller than the middle third, and taper gradually ; the one towards the anterior, the other towards the posterior extremity of the vertebral column. A streak of black pigment runs along the middle of the upper surface of the cord. It is situated in the groove already described, and is in greater abundance anteriorly and posteriorly, where the nerves pass off at shorter intervals, than at the middle or broadest part of the organ. From fifty-five to sixty nerves pass off from each side of the cord ; but, as the anterior and posterior vertebræ are very minute, and run into one another, and as the spinal cord itself almost disappears at the two extremities, it is impossible to ascertain the exact number, either of vertebræ or of spinal nerves. These nerves are not connected to the spinal marrow by double roots, but are inserted at once into its edges in the form of simple cords.

The nerves pass out of the intervertebral foramina of the membranous spinal canal, divide into two sets of branches, one of which run up between the dorsal muscular bundles (dorsal branches) ; the other (ventral branches) run obliquely

downwards and backwards on the surface of the fibrous sheath of the vertebral column; attach themselves to the antero-posterior aspect of each of the inferior muscular bundles, and may be distinctly traced beyond the extremity of each bundle. When an entire animal is examined by transmitted light, and a sufficient magnifying power, the anterior extremity of the spinal cord is observed, as before mentioned, to terminate in a minute filament above the anterior extremity of the vertebral column. The first pair of nerves is excessively minute, and passes into the membranous parts at the anterior superior angle of the mouth. The second pair is considerably larger, and, like the first pair, passes out of the canal in front of the anterior muscular bundle. The second pair immediately sends a considerable branch (corresponding to the dorsal branches of the other nerves) upwards and backwards, along the anterior edge of the first dorsal muscular bundle. This branch joins the dorsal branch of the third pair, and, passing on, joins a considerable number of these in succession, and at last becomes too minute to be traced farther. After sending off this dorsal branch, the second pair passes downwards, and backwards on each side above the hyoid apparatus and joins all the ventral branches of the other spinal nerves in succession, as its dorsal branch did along the back. This ventral branch of the second pair is very conspicuous, and may be easily traced along the line formed by the inferior extremities of the ventral divisions of the muscular bundles, the ventral branches of the other nerves joining it at acute angles between each bundle. It may be traced beyond the anus, but is lost sight of near the extremity of the tail. Twigs undoubtedly pass from the spinal and lateral nerves towards the abdominal surface of the body, but, on account of their minuteness, and the difficulty of detecting them in detached portions of the abdominal membrane, they could not be satisfactorily seen.

When a portion of the spinal cord is examined under a

sufficient magnifying power, it is seen to be composed entirely of nucleated cells, very loosely attached to one another, but enclosed in an excessively delicate covering of pia mater. The cells are not arranged in any definite direction, except in the middle third of the cord, where they assume a longitudinal linear direction, but without altering their primitive spherical form. The black pigment, formerly mentioned as existing more particularly on the upper surface and groove, is observed to be more abundant opposite the origin of the nerves ; and, as it is regularly arranged in this manner in dark masses along the anterior and posterior thirds of the cord, the organ in these places, on superficial inspection, resembles much the abdominal ganglionic cord of an annulose animal. Along the middle third the pigment is not so regular, but appears in spots at short intervals. When any portion of the cord, however, is slightly compressed, and microscopically examined, it becomes evident that there is, along the groove and mesial line of its upper surface, a band, consisting of cells of a larger size than those composing the rest of the organ. Some of these cells only are filled with black pigment, but all of them contain a fluid of a brown tint, which renders the tract of large cells distinctly visible. When the compression is increased the cells burst ; and the fluid which flows from the central tract is seen to contain jet black granules, which may be detected as they escape from the cells.

The nerves consist of primitive fibres, of a cylindrical shape, with faint longitudinal striæ. The primitive fibres of a trunk pass off into a branch, in the usual way, without dividing ; and, where the trunks join the spinal cord, the primitive fibres are seen to approach close to it, but without passing into it. The greater part of the slightly protuberant origin consisting of the nucleated cells of the cord, with a few pigment cells interspersed, the exact mode of termination of the central extremities of the primitive nervous fibres could not be detected.

Muscular System.

This system is highly symmetrical, consisting of a series of lateral muscular bundles, corresponding in number, size, and position, to the vertebræ of the "chorda dorsalis." These bundles have a general resemblance to the division of the lateral muscles of the higher fishes. Each bundle consists of a dorsal and ventral portion. The dorsal passes from the lateral line, on a level with the vertebral column, backwards and upwards; the ventral passes from the same level, downwards and backwards. The inferior bundle is the longest; and both of them have a somewhat conical shape, and are attached to the spinal column and skin by the aponeurotic septa formerly described. The fibres of these muscles pass respectively from before, obliquely upwards and downwards almost, but not completely, in the direction of the muscular bundle, along that portion of the trunk occupied by the branchial portion of the intestinal tube. The ventral bundles pass half-way over the dilated cavity, and terminate in blunted extremities, which are attached to the skin, and to the walls of the branchial compartment, so as to dilate it for the reception of sea-water. Beyond the anus the ventral bundles are attached to each side of the fibrous septum above described, meeting below in a sharp ridge. Between the anus and the branchial cavity, where these muscles inclose the digestive portion of the intestinal tube, they do not meet completely below, but are connected by an aponeurosis, which forms a strong tendinous arch at the point in front, where the muscles separate more completely. The whole cavity of the trunk, which is occupied by the intestinal tube, is lined by a fine aponeurotic membrane, which, about the lower edge of the lateral muscles, becomes muscular, and shuts in the whole of the inferior part of the trunk from the mouth to the tendinous arch formerly described. This abdominal muscle consists of two layers

—an external, apparently longitudinal; an internal, transverse.

The only muscle in the Lancelet for performing a special function is a flat bundle, connecting and bringing together the two halves of the hyoid apparatus, for the purpose of closing the mouth.

Under the microscope the primitive fibres of the lateral muscles exhibit the usual transverse striæ, but are not collected into fasciculi, constituting immediately the mass of the tissue. Transverse striæ are not observable in the fibres of the abdominal muscle.

Intestinal System.

This system appears as a tube passing nearly in a straight line from mouth to anus. It consists of two portions—an anterior, large and dilated, and appropriated to the respiratory function; and a posterior, small, of pretty uniform calibre, and constituting the proper digestive apparatus. The respiratory portion of the canal will be described afterwards in connection with the vascular system. The mode in which the digestive communicates with the branchial department of the tube could not be satisfactorily made out. It appeared, however, that the branchial cavity, becoming smaller, curved slightly of itself towards the left side, and then proceeded directly, and without any change in its calibre, to the anus. The anus is in the form of a longitudinal slit.

There is not the slightest trace of a liver, or of any other assistant chylopoietic viscus. The gut was full of a brown granular matter, tinged, probably, by a bilious secretion from the walls of the bowel.

Respiratory System.

This system is constituted by the anterior compartment of

the intestinal tube, on the walls of which a peculiar vascular arrangement exists for the aeration of the blood, and the complicated skeleton superadded, for the efficient performance of that function.

In connection with the respiratory apparatus, I shall, as formerly proposed, describe the splanchno-skeleton. This division of the osseous system consists of a hyoid apparatus and of a range of branchial ribs.

The hyoid apparatus supports the mouth, and guards its entrance. The mouth is in the form of a longitudinal slit, and is bounded on each side by the two divisions of the hyoid apparatus. Each of these consists of seventeen pieces articulated together. From each of these pieces, except the first, a ray proceeds, those at the extremities of the two divisions being shorter than those at the centre. The anterior extremities of the two divisions, or branches of the apparatus, meet at the anterior superior angle of the mouth ; and the two posterior, after curving forward, meet at the posterior inferior angle. The various pieces of which this apparatus consists have the consistence of cartilage. They are hollow along the bases, and to the points of the rays. Their cavities appear to be full of a transparent fluid containing here and there masses of globular cells, exactly similar to those in the interspinous bones. This part of the skeleton is covered by the integuments, and by the membrane of the branchial cavity. A fringe of the integument surrounds the hyoid rays, extending a little beyond their bases. This fringe must be considered as the lip or margin of the mouth, the hyoid rays, although occasionally dependent, belonging properly to the cavity of the mouth. The rami of the hyoid are brought together, and the mouth closed, by the transverse muscle formerly described.

Immediately behind the hyoid apparatus the branchial cavity commences, and continues as a dilated tube, which at last contracts, and becomes continuous, as formerly described

with the digestive portion of the intestine. The walls of the two anterior thirds of the branchial cavity are strengthened on each side by a series of transparent cartilaginous, highly elastic, hair-like ribs, which are imbedded in their substance. The upper extremities of these ribs are fixed in two streaks of a tough white substance, which runs along on each side of the inferior surface of the chorda dorsalis, on the sides of the inferior longitudinal ligament. The inferior extremities of the ribs terminate in a more complicated manner. Each alternate pair of ribs bifurcates. The inferior branch of the rib on each side meets its fellow of the opposite side at an angle in the median line. The superior branch curves up also, and meets that of the other side. The non-bifurcated ribs are shorter, and terminate in a line with the bifurcation of the neighbouring pairs. There results from this arrangement a sort of skeleton canal, the walls of which are completed by membrane. There are from seventy to eighty ribs on each side. Their general direction is from above downwards and from before backwards, but more perpendicular than the ventral bundles of the lateral muscles, with which they form acute angles. Along the edges of these ribs vessels pass for the performance of the respiratory function, and the canal above described contains the branchial artery or heart.

Vascular System.

In the canal which has been described as passing along the inferior wall of the branchial compartment of the intestinal tube, a vessel runs. This vessel diminishes anteriorly; and, posteriorly, it also diminishes, and is lost in the direction of the digestive tube. Valves, if they exist, have not been detected in this tube. At the extremities of each pair of bifurcated ribs, the abdominal vessel just described gives off a primary branch, which passes along the edge of the rib, sending secondary branches at regular intervals and at right angles to the other primary branches on each side. Along

the opposite sides of all the ribs another set of vessels may be seen, passing on to the chorda dorsalis, enlarging as they advance, and sending off secondary branches at right angles. When near the heads of the ribs, these vessels anastomose in semicircular loops, the canals of which are of large calibre, and the walls provided with distinct circular fibres. From the angles between each of these loops, and continuous, therefore, with the primary branches, smaller trunks pass on to the median line, and enter, opposite to their fellow at the other side, into a small longitudinal vessel which runs along the whole length of the chorda dorsalis, between the heads of the ribs, and on the inferior surface of the inferior longitudinal ligament. This vessel is the Aorta, and distributes arterial branches to the various parts of the body.

Generative System.

This system consists of a series of somewhat irregular, bean-shaped, granular bodies, situated each on the inside of the inferior extremity of the ventral portions of twenty or thirty of the muscular bundles of the middle third of the animal. These masses are attached to the internal surface of the aponeurotic lining of the abdomen, on the outside of the branchial chamber. No duct or outlet could be detected. Each mass, under the microscope, displayed a congeries of cells of various sizes, evidently incipient ova or sperm cells. The individual did not appear to be in season.

Tegumentary System.

The skin is remarkably thin, but tough ; and exhibits neither scales, pigment, nor metallic lustre, except at the base of the dorsal fin, along which, or the upper edge of the interspinous bones, a silvery band of considerable strength passes. The skin, under the microscope, displays minute parallel striæ, which occasionally cross one another. The beautiful iridescent tints which it exhibits, both before and after detach-

ment, appear to be caused by these striæ; and the same structure probably produces similar phenomena in the aponeurosis which lines the cavity of the abdomen.

Concluding Remarks.

At a very early period in the development of every vertebrated animal, the cerebro-spinal axis presents the appearance of a white elongated streak. At the same period, and in accordance with this simple condition of the nervous central organ, the skeleton consists of a chorda dorsalis, and very soon afterwards, of some of the peripheral elements of the spinal column. A central organ of circulation, in the form of a tube on the anterior inferior aspect of the embryo, invariably coexists with the simplest forms of the nervous and osseous systems. Branchial clefts and a liver are parts of the embryo of the vertebrated animal which are never found to accompany a cerebro-spinal axis of the simplest form, or a heart before it becomes divided into compartments.

No adult vertebrated animal has hitherto been described which at all approaches in organisation the simplicity of the embryonic forms to which allusion has just been made. Such an animal, a being perfected before the appearance of branchial clefts, might have been conceived; and, from the laws of organic development, its position in the system might have been indicated. As *Amphioxus* makes a close approximation to this simplicity of type, it may be useful to consider the relation of its different organs one to another.

One of the most remarkable peculiarities in the Lancelet is the absence of the brain. Retzius, indeed, describes the spinal marrow as terminating considerably behind the anterior extremity of the chorda dorsalis, in a brain which exhibits scarcely any dilatation; but careful examination of the dissection of my own specimen, which I have also submitted to the inspection of Dr. John Reid, and of other competent judges, has convinced me that the spinal cord, which may be

traced with the greatest ease to within 1-16th of an inch of the extremity of the chorda dorsalis, does not dilate into a brain at all. It may be urged that we ought to consider the anterior half of the middle third of the spinal marrow, where it is most developed, to be the brain, and all that portion of the chorda dorsalis which is in connection with the branchial cavity, as the cranium. That this does not express the true relation of the parts, is evident from the fact, that this portion of the cord, to its very extremity, gives off nerves, which are too numerous to be considered as cerebral, but more especially from the mode of distribution of the first and second pairs, which, in my opinion, proves the anterior pointed extremity to be the representative of the brain of the more highly developed vertebrata. A brain of such simplicity necessarily precludes, on anatomical grounds alone, the existence of organs of vision and of hearing. These special organs, developed in the vertebrata at least, in a direct relation with the cephalic integuments and the brain, could not exist, even in the form of appreciable germs, in the Lancelet. The black spot which Retzius took for the rudiment of an eye may probably have been, what also deceived me at first, a portion of the black mud which floats about in the branchial cavity, and which adheres obstinately to the parts in the neighbourhood of the oral filaments. The first pair of nerves, although very minute, in accordance with the slight development of the parts about the snout, and the want of special organs of sense, might, from their position and relations, be considered as corresponding to the trifacial in the higher vertebrata. The second pair appears to be the vagus, not only from its distribution as a longitudinal filament on each side of the body, as in other fishes, but also from its relations to the hyoid apparatus and branchial cavity, to which division of organs the eighth pair in fishes is specially devoted. The distribution of a branch of this nerve, however, along the base of the dorsal fin, and the course of the posterior part of the main branch, would appear

to show that this nerve, which I have provisionally denominated the Vagus, is, in fact, the trifacial, which, in the higher fishes, is not only distributed to all the fins, but holds exactly the same relations to the dorsal and anal fins, and to the spinal nerves, as the nerve now under consideration in the Lancelet.

The peculiarities in the structure of the spinal cord are not less remarkable than those of its configuration. It is difficult to understand, according to the received opinions on the subject, how a spinal cord destitute of primitive fibres or tubes, and composed altogether of isolated cells, arranged in a linear direction only towards the middle of the cord, can transmit influences in any given direction; and more especially how the tract of black or grey matter, if it exercises any peculiar function (excito-motary) communicates with the origin of the nerves. The nerves, also, are remarkable, originating in single roots, and containing in their composition one kind only of primitive fibres (cylindrical).

In reference to the skeleton of the Lancelet, it is evidently of the simplest kind. If we limit the term skeleton to the Neuro-Skeleton, this animal possesses only the primitive form of such a skeleton—a chorda dorsalis without any cranial enlargement, with a dorsal and ventral series of germs of interspinous bones and fin rays—peripheral elements of a spinal column.

From a consideration of the particular class of embryonic forms to which this fish corresponds, we could not expect either bone or cartilage in the composition of its skeleton. Accordingly, the skeleton consists of a series of sacs, assuming particular forms according to their several positions: flattened in the chorda dorsalis, cylindrical in the fin bones. These sacs are easily derived, according to established histological laws, from the primitive nucleated cells which constitute the tissue of their representatives in the embryo, and contain, in their interior, cells, or the nuclei of cells. This view of the

tissue of the skeleton of the Lancelet is based on a law of organisation which is not usually recognised in questions like the present, viz.—that adult organs representing embryonic organs, are altered so as to be fit for the performance of their functions, but never so far as to depart, either in tissue or form, from the type of their corresponding embryonic organs. The arch-shaped fin rays, described by Mr. Couch, are merely the dissepiments between the cylindrical germs of the fin bones.

The leading peculiarity of the Lancelet, considered as a representative of an embryonic form in the adult series is the want of true gills or branchial arches—the deficiency of branchial clefts. Retzius, indeed, describes an opening at the posterior part of the branchial cavity, which he compares to the abdominal openings in the Myxine; but as I have been unable to discover this opening in my specimens, I agree with Müller in considering its existence as highly problematical, and I shall proceed to demonstrate that, in accordance with the plan on which the other organic systems of this animal are formed, such an opening into the branchial chamber could not exist. The abdominal openings in the Myxine are the result of the closure of its numerous branchial clefts by the integuments. They are analogous, in fact, to the branchial orifices of the tadpole, immediately before cessation of the aquatic respiration. The respiratory apparatus of the Myxine, then, although inferior in functional activity to that of other fishes, is actually referable to a more elevated type. The Myxine possesses a brain in which the central masses are considerably evolved, and a nervus vagus of sufficient development. The brain of the Lancelet, again, is reduced to a mere filament, and the existence of a nervus vagus appears to be highly problematical. These considerations, and the fact that branchial openings have not been detected by Yarrell, Couch, Müller, or myself, must lead to the conclusion that this fish has either never had branchial clefts at any period of its

existence, or that if it at any time had them, they must have totally disappeared. I am inclined to believe that the former is the real state of the case, not only from the views already urged in reference to the other organs in this animal, but also from the consideration that if these clefts had ever existed their traces would have remained. As the seventy or eighty pairs of branchial ribs cannot be looked upon as true branchial arches, and as we cannot suppose that any vertebrated animal could have so many branchial fissures, we are driven to the conclusion that the Lancelet never had at any period of its existence true branchial arches and clefts, and that the ribs have been developed for a special purpose—for a mode of branchial respiration hitherto undescribed in the class of fishes.

The Lancelet respires by receiving sea-water into the anterior compartment of its intestinal tube—this cavity is kept dilated by the elasticity of the numerous filamentous ribs, and this dilatation may be increased by the action of the superimposed ventral bundles of the lateral muscles. It is contracted by the action of the abdominal muscle. This is a mode of respiration similar to that which prevails in the tunicated molluscs. It is interesting to observe that the branchial membrane of the Lancelet is exactly similar in its peculiar vascularity (ramifications at right angles) to that which lines the branchial cavity of the molluscs just specified.

If the branchial membrane were examined in the living animal, it would undoubtedly exhibit cilia in as great abundance as in the branchial membrane of the *ascidiæ*, and such a ciliary arrangement must constitute one of the active agencies, not only in renewing the supply of water for respiration, but also in conveying food to the orifice of the digestive portion of the intestinal tube. As in the *ascidiæ*, the entrance of the intestino-respiratory canal is guarded by filaments. The hyoid filaments of the Lancelet performing the same office as the filaments at the oral orifice of the *ascidiæ*, acting as a sieve in preventing the entrance of foreign bodies, or of food,

which it has neither jaws to comminute, nor powers of stomach to digest.

The branchial ribs I do not consider as parts of the neuro-skeleton, as they bifurcate to enclose the heart, this organ in the Lancelet being contained in a sac resembling the cartilaginous pericardium of some other fishes. They are repetitions of the hyoid bone developed for a new form of branchial apparatus. They are true splanchno-ribs, parts of a splanchno-skeleton, and analogous to the cartilages of the trachea and branchial tubes (also repetitions of the hyoid bone) of the higher vertebrata. Some of these splanchno-ribs, had branchial clefts been developed, would have become true branchial arches; but just as in the vertebrata above the fishes, in which the branchial clefts have disappeared, and tracheal cartilages have become developed, so in this animal, in which the branchial clefts have never appeared, cartilaginous arches have become necessary for its peculiar aquatic respiration.

The hyoid filaments of the Lancelet must not be considered as the analogues of the branchiostegous rays, which spring from the peripheral aspect of the bone, but as developed forms of the teeth or tubercles which are ranged along the central aspect of the branchial apparatus of the higher fishes, and which are occasionally highly developed for similar purposes. As the upper jaw is developed from a cranium, and the lower jaw is formed at a period posterior to the appearance of the hyoid bone—the absence of these two bones is a necessary consequence of the inferior position of the Lancelet in the series of vertebrate forms.

The plan of the circulation is simple, and in accordance with the primitive condition of the respiratory apparatus, both functions being performed in a manner closely resembling that observed in certain annulose animals. The dorsal vessel corresponding to the heart or branchial artery, and the abdominal vessel to the aorta of the Lancelet, the lateral communicating vessels of certain of the rings in the annelide

performing the respiratory function, like the vessels of the branchial chamber already described. The development of cardiac septa and of a liver follow closely, if they do not accompany, the branchial fissures. The absence of such fissures in the Lancelet sufficiently explains this deficiency of parts usually considered essential to the vertebrated animal.

For similar reasons, true renal and generative organs do not appear in this animal.

The double row of isolated generative organs are in the normal position of their embryonic representatives, and not more advanced in organisation than the Wolffian bodies at their first appearance. How the contents of these ovisacs or spermsacs are conveyed to the exterior, it is difficult to say. If the abdominal opening described by Professor Retzius actually exists, it appears to me much more probable that it is an opening, not into the branchial, but into the peritoneal cavity, as in certain of the higher fishes, and that it performs the double function of admitting sea-water for peritoneal respiration, and for allowing of the exit of the ova and sperm from the cavity of the abdomen, into which they are cast from the glandular organs attached to its lining membrane. This hypothesis, which I have had no opportunity of verifying, gets rid of the difficulty in a satisfactory manner, explains to a certain extent the observation of Retzius, and is in accordance with the type of formation in the class.

Viewed as an entire animal, the Lancelet is the most aberrant in the vertebrate sub-kingdom. It connects the Vertebrata not only to the Annulose animals, but also through the medium of certain symmetrical ascidiæ (lately described by Mr. Forbes and myself),* to the Molluscs. We have only

* Report of the British Association, 1840, and No. XII. of this volume. An important observation, bearing on the affinities of the Ascidians and Amphioxus, has recently been made by the discovery by M. Kowalevsky of an axial cylinder in the tail of the Ascidian larva, which possesses almost the same structure as the chorda dorsalis of Amphioxus (Mem. de l'Acad. Imp. de

to suppose the Lancelet to have been developed from the dorsal aspect, the seat of its respiration to be transferred from its intestinal tube to a corresponding portion of its skin, and ganglia to be developed at the points of junction of one or more of its anterior spinal nerves, and inferior branch of its second pair, to have a true annulose animal, with its peculiar circulation, respiration, generative organs, and nervous system, with supra-œsophageal ganglia, and dorsal ganglionic recurrent nerve.

As some fishes undergo metamorphoses after leaving the ovum, the question naturally suggests itself, is the Lancelet an adult fish? May it not be the young of some fish in one of the stages of growth? The uniformity of every specimen of it hitherto described, and the peculiar toughness and firmness of its tissues, appear to be decisive of its being a perfect animal.

In regard to the zoological position of *Amphioxus*, Mr. Yarrell was correct in giving it the lowest place in the class of fishes; but if the details of its structure, and the anatomical considerations which this paper contains, be correct, the genus can no longer be retained in the same family with Petromyzon and Myxine, but will assume an ordinal value in any new arrangement of the class.

If genera allied to Amphioxus are at present in existence, they are probably not numerous; but in the ages which have passed since the development of animal forms commenced, abranchiated fishes may have been more common; and the paleontologist, when his attention is directed to the subject, may probably be able to refer some anomalous organic remains to extinct fishes of this order.

St. Petersbourg, vol. x.) In vol. xi. he has given an account of the development of Amphioxus. In the Bulletin of the same Academy, vol. xii. 1867, Owsjannikow describes the arrangement and structure of the nervous system in A. lanceolatus, which, though differing in some points, yet agrees in others with the statements made in the text.—Eds.

VII.—ON CERTAIN PECULIARITIES IN THE STRUCTURE OF THE SHORT SUN-FISH (ORTHAGORISCUS MOLA).*

THE anatomy of an animal or vegetable may be investigated and described with two objects in view ; first, the elucidation of its habits, and of its true place in the system ; or, secondly, the discovery of the laws which regulate organic form and tissue (Morphological and Teleological laws).

It is with the latter object in view that I have now to offer a few observations on certain peculiarities in the structure of the sun-fish, as confirmatory of some of the principles to which I have just alluded.

The anatomy of this fish has been investigated by Dr. Jacob, in a paper which I have not had an opportunity of consulting.† Cuvier and Meckel, in their Systems of Comparative Anatomy, have recorded its various peculiarities ; but as the observations of these anatomists have a reference to its general structure, I shall not have occasion to refer again to their labours.‡

The specimen I had an opportunity of examining was the very large individual lately procured for the Natural History

* Read before the Wernerian Soeiety, 12th Deeember 1840.

† *Dublin Philosophical Journal*, November 1826, referred to by Mr. Yarrell.

‡ Sinee this paper was written, l have seen a Leyden Inaugural Dissertation, May 1840, P. H. J. Wellenbergh, *Obscrvationes Anatomicæ de Orthragorisco Mola.* The author gives a detailed aeeount of the skeleton, intestinal eanal, and heart; but throws no light on any of the subjeets treated of by me.

Museum of the University of Edinburgh.* It measured 5 feet 8 inches from the snout to the tail, 3 feet 3 inches from the tip of the dorsal to the tip of the anal fin, and weighed 489 pounds.

On commencing to remove the skin, which was found to be rather a difficult operation, in consequence of the total deficiency of any structure resembling the dermis, I found that the coloured and tubercular layers of the integument were attached to the external surface of a structure or tissue of a very peculiar kind. This tissue extended in the form of a layer, varying from one-fourth of an inch to 6 inches in thickness, all over the body, head, and fins. It was thickest along the median line of the back and belly, of medium thickness along the sides, and thinnest on the surface of the fins. Large and thick masses of it enveloped the bones of the cranium, and enclosed the opercular laminæ and branchiostegous rays. The soft cartilaginous bones were imbedded in such a manner in its substance, that they presented the appearance of nuclei in it, and resembled the first traces of the skeleton in the early embryo. The most distant or peripheral elements of the skeleton, the fin-rays, and certain parts of the opercular apparatus, were so much softer and more delicate than the tissue in which they were imbedded, and so completely deficient in any periosteal covering, that they could only be discovered in the fresh state by their translucency.

This peculiar tissue was separated from the muscular substance in its neighbourhood by the ordinary loose filamentous structure (cellular membrane). Its relation to the skin was very peculiar. The tissue was inelastic, tough, of a dead white appearance resembling lard, granular when torn, and presented very slight traces of vascularity,

* This specimen was found in shallow water in the Firth of Forth at Culross, lying sluggishly on one side, but making vigorous resistance when attacked.

and these only in the neighbourhood of certain parts of the skeleton. It discharged no oil, but on standing a quantity of watery fluid exuded, and its bulk was considerably diminished. When boiled, it dissolved into a gelatinous mass, which passed in the form of a clear transparent liquid through flannel. A few shreds of animal matter remained. This fluid on cooling became a fine jelly, inodorous and tasteless. The greater part of this tissue, then, is composed of or may be converted into gelatine.*

There was no trace of dermis or true skin, the coloured lamina of the integument appearing to be merely the superficial layer of the peculiar cellular tissue, changed by the deposition of colouring matter in the cells to adapt it to its proper function. The peculiar tissue must either be looked upon as the true skin itself, or more correctly it must be considered as the primitive nucleated vesicular tissue of the embryo fish, from which the pigmentary and tubercular layers of the skin have already been developed, but from which the conversion into true skin has not begun, and that of the peripheral bones has been arrested.†

* I am indebted to Dr. Aitken for this account of the chemical constitution of the tissue.

[We have not reprinted the paragraph on the minute structure of this tissue, as the examination was made with a doublet, and the description given has since been superseded. We may refer to the more recent accounts of the anatomy of this fish, from the dissection of specimens provided by Mr. Goodsir, by Professors Cleland and Turner in the *Natural History Review*, 1862, and to the description by Professor Harting of an *Orthragoriscus ozodura* in the *Verhandelingen der Koninklijke Akademie*, Amsterdam, 1868.—Eds.]

† Meckel, *Comparative Anatomy*, French edition, tom v. p. 185. According to the observations of Dr. Jacob, in the *Dublin Philosophical Journal*, the cetacea have no dermis, except we consider, along with him, that the blubber is the true skin distended with oil. The subcutaneous fat of the cetacea, however, differs from the gelatinous vesicular tissue of the sun-fish in having no primitive cells in its constitution, consisting of common fibrous tissue inclosing in its areolæ fat or oil-cells. It may, nevertheless, be considered as a tissue in which some of the primitive cells have been developed into fibrous tissue, while others have become filled with oil.

From what I have now stated, it is evident that the interest to be attached to this tissue consists in its purely embryonic character. The general appearance of the cells, their nuclei and nucleoli, the uniformity of the tissue in every part of the animal, and its chemical composition, all indicate this character; and when taken in connection with the embryonic state of the bony tissue, and the rudimentary condition of the muscular system, forms a very interesting and important character in the species, and probably in the order of fishes to which the one under consideration belongs.

In a teleological point of view it is important, as it points to the existence of certain laws which regulate the development of animal tissues—namely, first, *In the organic series, tissues as well as forms undergo progressive development;* secondly, *This progressive development of the tissues may be retarded, retaining their early embryonic condition in certain beings in the series;* and, thirdly, *Tissue is subordinate to form.** A sun-fish, in fact, as well as other fishes of its order, is as highly developed, in so far as regards form, as any in the class; in certain of its tissues it is still in the condition of an embryo.

A second peculiarity to which I shall refer, is the form of the caudal fin of the *orthagoriscus.* The naturalist is familiar with its truncated shape, but the anatomist has not yet ascertained the cause of the peculiarity of this part of the skeleton.†

* For an exposition of this last law of organisation, see Dr. Martin Barry's Memoir on Embryology, 2d series, *Phil. Trans.* 1839.

† Meckel, *Comparative Anatomy*, French edition, tom. ii. p. 285. For a drawing of the tail, which appears to have been made from a dried skeleton, see Dr. C. A. S. Schultze, "Ueber die ersten Spuren des Knochensystems, und die Entwickelung der Wirbelsaule, in den Thieren."—Meckel's *Archivs*, 1818. Willenbergh's drawing, which he states was made from a dried skeleton, is incorrect in the mode of junction of the pectoral girdle to the spine, but more particularly in the mal-representation of the mode of termination of the spinal column. He has mistaken the two or three last vertebræ for a fin-ray and interspinous bone.

I found that the rays of the tail-fin, and their interspinous bones, were crowded together in a direction from behind forwards, and abutted against the superior spinous process of the fourteenth and the inferior spinous process of the fifteenth vertebra. The sixteenth, seventeenth, and eighteenth vertebræ assumed the appearance, the two former combined, of an interspinous bone, and the latter of a fin-ray, and could not have been distinguished from these but by their direct continuation with the bodies of the vertebræ, and their more cylindrical and shorter form. The joint between the seventeenth and eighteenth was in the line of the articulations of the fin-rays and their interspinous bones, the ultimate vertebra assuming the appearance and function of a fin-ray, the penultimate and antepenultimate combined of an interspinous bone.

The interest involved in this form of skeleton consists in the explanation it affords of the true nature of the so-called last vertebra in the spinal column of fishes. Is that fan-shaped bone a vertebra? or is it a composite bone, containing the elements of a number of vertebræ and of interspinous bones of fin-rays? I have always been led to conclude that it is a composite bone, and it required only such an arrangement of skeleton as that now under consideration to afford a natural analysis of the tail in this class of fishes, and to prove the correctness of the opinion to which I have just alluded. In many of the osseous fishes the last bone of the spine exhibits traces of a central element, and in some families (Tænioides) it appears to be prolonged far beyond the caudal fin, in the form of a fine filament, but in none, as far as I am aware, is it arranged as in the present instance.

The next peculiarity is in the muscular system. The sunfish exhibits not a trace of abdominal muscles.* The viscera from the spine to the median line of the belly are inclosed by

* Meckel, *Comparative Anatomy*, tom. v. p. 185.

abdominal walls, consisting of peritoneum on the internal surface, of skin on the external, and of a thick layer (4 or 6 inches) of the peculiar tissue already described between them. This is a conformation exactly corresponding with the embryonic condition of all the vertebrata. The abdominal muscles are among the last to be developed, in consequence, in a great measure, of the persistence of the yolk-bag, and the evolution of the abdominal walls from the dorsal towards the ventral aspect.

The muscles of the spine, also, instead of stretching from head to tail, are reduced to a very small size, and constitute only a weak fan-shaped muscle on each side of the caudal fin. These muscles consist of a small digitation for each of the fin-rays, and appear to me rather to be analogous to the caudal-fin muscles of other fishes than to the great lateral muscles of the spine.

The thick mass of muscle on each side of the sun-fish consists of the muscles of the anal and dorsal fins ; very weak in other fishes, but developed here in an extraordinary manner—in an inverse ratio to the spinal muscles.* This inversion of the muscular masses depends on the stunted condition of the vertebral column, and on the developed state (in regard to form) of the peripheral elements of the skeleton, and is an instance of the dependence of one organic system on another. The morphological cause of the stunting of the

* Meckel, *Comparative Anatomy*, tom. v. p. 185, inclines to the opinion that the dorsal portion of the lateral fleshy mass of the sun-fish is a composite muscle, consisting of the anterior part of the usual lateral spinal muscles, and of the muscles of the dorsal fin ; or that the latter had assumed the form and position of the former. I have, however, satisfied myself that this mass, although extending forwards to the head, is in fact the fin-muscle, and that it consists of uninterrupted radiating bundles. The body of this fish, then, contains only six muscles—two for each fin. It appears to swim by a sculling action of the dorsal and anal fins, the tail being a very inefficient organ of locomotion.

column is still a problem,* and must be sought for, probably, as a circumstance connected with the development. Whatever it may be, it must be considered as the means of adapting the structure of the animal to some peculiarity in its habits or economy.

* I have not assumed the short spinal cord of the *Orthagoriscus mola* as the cause of the stunting of the osseous column, as there are contradictory facts which must be explained before we can connect the length of the latter in the embryonic and adult series with the length of the former.

VIII.—ON GYMNORHYNCHUS HORRIDUS, A NEW CESTOID ENTOZOON.* (PLATE VI. p. 445, vol. ii.)

THE genus Gymnorhynchus was instituted by Rudolphi, for the reception of a worm which infests the muscular tissue of the *Brama Raji*, and which had been placed by Cuvier in the genus *Scolex.* This worm, *Gymnorhynchus reptans* (Rudolphi), *Scolex gigas* (Cuvier), is the only species which has been hitherto observed. It is described by Rudolphi, Cuvier, Blainville, and Milne Edwards, and figured by Bremser. The characters of this genus, according to Rudolphi, are :—Body depressed, continuous, very long, with a subglobose cervical receptacle ; head provided with two bipartite suckers, and emitting four naked retractile proboscides. Bremser, however, represents in his atlas the four proboscides not as naked, but as armed with recurved hooks, an arrangement which can only be recognised when they are fully extended. Milne Edwards, in the last edition of Lamarck's Invertebrate Animals, has defined the genus thus :—Body depressed, continuous, or without articulations, composed of three parts ; one median, subglobose, prolonged backwards into a very long tail, and forwards into a wrinkled neck ; the cephalic bulging provided with two bipartite suckers and four papillose tentacula.

When dissecting the sun-fish, which formed the subject of a former communication to the Society, I found in the liver a number of entozoa which presented a very curious appear-

* Read before the Wernerian Natural History Society, February 20, 1841.

[Dr. Cobbold, in his Treatise on the Entozoa places this parasite amongst the *Tetrarhynchidæ*, and names it *Tetrarhynchus reptans.*—EDS.]

ance. They were cylindrical, very much elongated, coiled and twisted on the surface and in the substance of the organ, one of their extremities subglobose, and situate immediately under the peritoneum, the other tapering to a fine point. They adhered to the parenchyma of the organ by cellular tissue, and occasionally, where one coil lay over the other, the two adhered. Their colour was cream-white, so that they contrasted strongly with the deep brown of the liver.

On removing one of them, and making a longitudinal incision, I found that it was not a worm, but an elongated sac or cyst containing a worm, which, when withdrawn, was found to be alive, although the fish had been a week dead. When placed in lukewarm water, it pushed out its head and neck from the cervical receptacle, protruded the four-armed tentacula, and continued in lively motion for some hours. The globose receptacle, with the head and neck of the worm, were lodged in the bulbous extremity of the cyst, but the tail did not extend into the attenuated extremity.

I had no difficulty in referring the worm to the genus Gymnorhynchus. I may remark, however, that it presented one character not included in the definition of this genus. It exhibited, when gently compressed between two plates of glass, distant, but distinct articulations. From an examination of Bremser's drawing, and a consideration of the relations of the genus, I strongly suspect that the old species is also articulated, and that such a conformation must be considered as a character of this cestoid genus. My specimens present a character which appears to be sufficient to distinguish them as a new species. They have a separate circle of large recurved hooks on the tentacula, an arrangement not to be seen in Bremser's figure of *Gymnorhynchus reptans*.

The cyst enclosing the worm is double. The outer coat is

rough, flocculent, and adherent to the parenchyma of the liver. The anterior extremity is dilated, and in all the specimens was situate immediately under the peritoneum. The posterior extremity, again, was so attenuated that it was traced with great difficulty, as it lay coiled about in all directions through the substance of the organ. Within the outer coat another cyst is situate closely investing the worm ; it is smooth, transparent, thin, and elastic, and does not adhere to the outer. The worm is visible through this second tunic, and lies with its anterior bulbous extremity packed up in the vesicular portion of the cyst. When one of the animals was released from its prison, and placed in water, it dilated its anterior extremity, and projected its head and neck. The head and neck, when withdrawn, are lodged in the cervical receptacle. There is no particular muscular arrangement to effect this. The tissue of this, as well as of the rest of the animal, was the primitive granular tissue lately described by Mr. Forbes. The four-armed tentacula are retracted by four distinct muscles, all of which consist of granular tissue. The arrangement of this part of the animal corresponds exactly with the same part in the *Bothriocephalus corollatus* as described by Leblond in the *Annales des Sciences Naturelles*, 1836. The motion of these parts in both animals is similar, and the tissue is identical with that denominated by Leblond "Sarcode," or elementary texture, the granular tissue to which I have already referred.

The body, when gently compressed between two plates of glass, exhibited transparent transverse articulations at distances of one-third to half-an-inch. The most careful examination, however, revealed no nutritive or generative organs in any of the segments. The dilated cervical receptacle, into which the head is retracted, did not appear to communicate with any arrangement of tubes or cavities in the elongated body.

The most interesting circumstance in the history of this

entozoon, is the manner in which it is enclosed in a firm and close cyst. It appears to me that this cyst is not altogether the result of irritation of the surrounding tissues. The outer coat of the cyst may be of this nature, but it is not so easy to conceive the inner tunic to be due to the same cause. Professor Owen, in his memoir on the *Trichina spiralis*—the entozoon of the human muscles—holds that the cyst of that animal, although apparently consisting of two tunics, is the result of irritation. Dr. Knox, again, considers it to be a part of the animal, although the latter lies free in the cavity. This latter opinion is inadmissible, according to the usual conception of an individual animal. Might we not conceive the cysts to be essential parts of all such entozoa, inasmuch as they are never absent? and may we not suppose them to be parts of the original ovum within which the animal was formed, and in which it passes the term of its existence? Without having any facts to adduce in proof, I hazard this supposition as a hint for future research; and as it is not at variance with any of the known conditions of animal existence, it is worth consideration in a fresh investigation of the subject.

IX.—ON THE STRUCTURE AND ECONOMY OF TETHEA.*

I AM indebted to Mr. Guerin, one of my pupils, for the specimens of the undescribed Tethea, to the structure and economy of which I am about to direct the attention of the Society. He procured them, along with many other specimens, by dredging in deep water on the south-west coast of Spitzbergen. They have been carefully preserved in alcohol, and are in as favourable a state for examination as their delicate texture will permit.

These specimens present the globose or sub-globose form peculiar to the group ; but two of them contract towards their attachments, so as to resemble inverted cones, with spheroidal bases (*Tythea turbinato-capita*—Lamarck).

The largest spherical specimen measured 4 inches in diameter ; the smallest $2\frac{1}{2}$. The turbinated specimens are 3 and $2\frac{1}{2}$ inches long by $2\frac{1}{2}$ and 2 broad.

Their colour is dark-grey when removed from the alcohol ; but when in that fluid light lemon-yellow, on the dense, fleshy, and more recently-formed parts of their surfaces, and grey or dark grey where the downward and projecting spicula abound, and where mud and debris, in greater or less abundance, lodge in the crevices.

The *debris*, or pellicle apparently exfoliated from the organism, appears to be entangled among the projecting spicula on various parts of the surface in such a manner as to

* Read before the Royal Society of Edinburgh, 7th March 1853.

enclose polygonal spaces, generally hexagonal when complete and well marked.

On the dark-grey portions of the surface, where the projecting spicula are very numerous, the character of the surface itself cannot be recognised; on the lemon-yellow fleshy portions, from which the naked spicula do not project, numerous darkish spots are visible, of a polygonal form, and separated by light yellow bands arranged in a sort of network. These spots, under a lens of 1 or 2 inches' focus, appear to be perforated, and have a general resemblance to the pores of the afferent orifices of the denser sorts of sponges.

On various parts of the surface, but more abundantly towards the attached pole of the mass, there are a variable number of serpentine semi-cylindrical grooves, elongated, ramified, and continuous, or short and disconnected. The floor and walls of these grooves consist of a membrane perforated throughout by angular or rounded orifices, so as to resemble an irregular network. The grooves may be here and there observed to pass into deep fissures or vents in the substance of the organism. These fissures tend towards the centre in the direction of its long spicula, the bundles of which may be observed passing into the interior on the walls of the fissures. At the junction of the grooves and fissures the perforated membranes of the former terminate in bands and lamellæ, suggesting the idea that the grooves are former fissures closed in by the growth of the perforated membrane. At these junctions also it may be observed that the recent fissures are actually continúous with spacious cavities under the perforated membrane, resembling fissures with their deeper angular portions filled up and rounded off by new sponge-texture, and traversed in their wider parts by bands and lamellæ attached to their walls and the deep surface of the perforated membrane for the support of the latter.

The perforated grooves are invariably situated on parts of

the surface from which the spicula project in greatest abundance. The spicula are arranged in great numbers along the margins of the grooves, projecting obliquely over them from their opposite margins, like palisades along the faces of a ditch. The fissures, unlike the grooves, are situated in the fleshy and apparently more recently-formed portions of the surface.

The character of the perforated grooves associates them with the oscula or feculent orifices of the typical sponges.

On tearing a specimen through the centre, the arrangement of the nuclear radiating structure and veins peculiar to Tethea may be observed. The central nucleus is not so apparent—fleshy substance, with small areolar spaces, predominating over the spicular structure. The radiating masses of fleshy substance, with their bundles of spicula, are well marked. Numerous canals converge between the radiating columns towards the centre, gradually degenerating, by frequent anastomoses, into freely communicating areolar spaces. Other canals of larger size, and lined by a semi-opaque membrane, collect obliquely across the radiating masses towards the perforated grooves on the surface.

The peripheral rind peculiar to Tethea does not exist over the whole surface of these specimens. It is also comparatively thinner than in *T. cranium.* Of a grey gelatinous aspect, it is thickest on the lemon-yellow fleshy portions ; thinner, and apparently not so solid, on the portions of surface from which the spicula begin to project. It has disappeared entirely where the spicula are most numerous and projecting. The canals of the intermediate or radiating masses become much smaller and more numerous as they pass through the rind, on the surface of which they open in the dark spots.

Particular Description.

The Skelcton.—The skeleton of this sponge, like those of

the group to which it belongs, consists of silicious spicula bound together by horny matter.

The spicula of which the skeleton is essentially composed present the following forms :—

1. Tubular, elongated, somewhat flattened, pointed, or truncated spicula, slightly bent or twisted, with an average length of one line and a half, but of various smaller sizes.

2. A similar form, but terminated at one end in a spherical head, and very rare.

3. Tubular, elongated, cylindrical, straight spicula, one line and a half in average length.

4. Very slender spicula, of uniform thickness, short, with both ends bent towards one another.

5. Similar spicula, with their ends bent in opposite directions ; sigmoidal.

6. Tri-radiate spicula in two forms.

7. Six-radiate spicula.

8. Stellate spicula.

Viewed as a whole, the skeleton may be divided into a *central* and a *peripheral* portion.

The *central* portion may be considered as consisting of two parts, as it is arranged in the nucleus, and among the radiating masses.

The nuclear portion consists of single spicula, and bundles of spicula of the 1st, 2d, 3d, 4th, and 5th orders, bound together and arranged so as to form a mesh-work to support the walls of the areolar water-passages of the nucleus.

The radiating part consists of thick trunk-like bundles of the same kinds of spicula, springing from, and tied to, the nuclear part. These trunks ramify as they radiate, so as to be resolved at or near the surface into numerous nearly uniform bundles, which in the recently-formed rind pass through between the six-radiate spicula, and elevate, to a greater or less extent, the free surface; but when the rind is of older

date, or has disappeared, they project more or less from the surface, the individual spicula becoming denuded, and diverging in various or definite directions from one another.

The peripheral portion of the skeleton is peculiar to the rind, and only exists therefore on the lemon-yellow and light-grey portions of the surface.

It consists essentially of the tri-radiate and six-radiate spicula; but intermingled with the extremities of the terminal bundles of the central part of the skeleton, the spicula of which pass into the rind towards or through its free surface.

The shafts of the tri-radiate spicula pass through the rind, deep into the radiating masses of the sponge, packed into the centre or attached to the surface of certain of the terminal bundles of the central portion of the skeleton; from the spicula of which they may be distinguished by their tapering form, peculiar twist, and greater opacity.

The radiating branches of the tri-radiate or six-radiate spicula are imbedded in the substance or on the surface of the recently-formed rind. But in rind of older date many of them project, as if their shafts had been pushed outwards, so that their radiations are suspended horizontally at a greater or less distance from the free surface of the sponge.

When a section of the rind is made towards the centre of the sponge, the radiations of these spicula may be observed in profile, arranged parallel to and at various distances from the free surface.

When the free surface of a recently-formed portion of the rind is strongly illuminated by a condenser, and examined by a 1-inch or 2-inch objective, the radiating branches of the superimposed spicula may be brought into view in succession, from the free surface inwards, by slowly altering the focus of the instrument.

I have endeavoured to ascertain whether the six-radiate

spicula are arranged symmetrically so as to circumscribe the peculiar polygonal figures which must result therefrom. I have, however, hitherto failed, either because the eye is unable in the maze of crossing spicular branches to isolate the pattern ; or because they have been disarranged, as I am inclined to believe they are, first, in consequence of the varied development of the intervening soft textures, the result of varied conditions ; and secondly, in consequence of the oblique course of the water-passages which they support.

In addition to this arrangement of radiated spicula, the peripheral portion of the skeleton consists of the divergent naked, or imbedded spicula of the terminal branches of the central portion. The greater number of these appear to me to pass on or through the spaces inclosed by the rectangular secondary branches of the six-radiate spicula; and from this circumstance, as well as from the fact of the projecting but still imbedded spicula forming conical tubercles or thin spaces, I am inclined to consider these spaces (which are also, from the form of the six-radiate spicula, somewhat elevated) as the parts of the surface set aside for the cutaneous attachments of the central portion of the skeleton, and as homologous in this new form of Tethea to the conical elevations of *T. cranium*, or hemispherical bulgings of *T. lyncurium*.

I have already stated the general characters of the different kinds of spicula which I have observed in this sponge, but the very interesting nature of these silicious structures demands a few additional remarks.

Into the consideration of their chemical composition I shall not at present attempt to enter.

I am rather anxious to direct attention to their exact *configuration* and to their *mode of development*.

From the comparatively large size of the elongated spicula of this species of Tethea, I am strongly confirmed in an opinion which I have long entertained from the examination

of other silicious sponges, that these structures possess precise geometrical forms. I am not prepared at present to enter into details, for the subject is one beset with many difficulties, but I may state generally—1st, That all silicious spicula, with *continuous margins* and *pointed, rounded,* or *apparently truncated extremities,* are, in fact, *oblong ellipsoids or ovoids, more or less compressed or not in the direction of their conjugate diameter,* and more or less *spirally twisted or not around their transverse diameters;* 2d, That all the forms of unbranched spicula are reducible to *ellipsoids* or *ovoids*, or to *linear combinations of these;* and, 3d, That the radiations of the branched spicula are not only portions of *ellipsoids* or *ovoids*, but are arranged in reference to one another at definite angles.

No one, as far as I am aware, has hitherto investigated the mode of development of the silicious spicula. Dr. Grant in *Halichondria*, and Mr. Carter in *Spongilla*, have observed them forming in the embryo sponge, but the combination of structures by which a spiculum is laid down has not been noted. Dr. Grant, indeed, appears to consider the spicula crystalline productions ; but the general existence of a cavity in their interior, the animal matter which they contain, the peculiar forms which it is generally admitted they present—all tend to prove their organic origin, and clearly to distinguish them from raphides or ordinary crystals.

As the formation of bone, shell, tooth, hair, and other calcareous and horny structures, has now been ascertained to depend on the deposit of calcareous salts and horny matter in nucleated particles peculiarly figured and arranged, it becomes important to determine whether the silicious spicula of the sponges are developed in a similar manner. I have not been able hitherto to procure any observations bearing directly on this question, but the general considerations and structural arrangements appear to me to indicate clearly a law of de-

velopment of these bodies, which I would thus state provisionally :—*A spiculum is formed by a series of sponge-particles, so arranged in a column or system as, by the silicification of more or less of their contiguous surfaces and substance, to form a continuous rod.*

Mode of union of different parts of Skeleton.—Horny matter of the same nature as the peculiar substance which forms the entire skeleton of the keratose sponges, but more delicate and transparent, binds together the spicula, and connects the fasciculi of the central portion of the framework.

The diminished quantity and greater delicacy of the horny connecting matter in the Tethea now under consideration, as well as in *Tethea cranium*, appears to me to depend on the greater contractility of the soft texture of these sponges.

Towards the periphery of the intermediate or radiating masses, the long spicula are bound together by numerous fibre-cells, which may be contractile, but from their thin and dry aspect, I am inclined to consider them as ligamentous, and consequently better adapted to the movements of the various parts of this sponge than the elastic but more rigid horny texture.

The minute curved spicula, which are not very numerous, are always to be found arranged across the long spicula ; and as their length nearly corresponds to the breadth of a pair of the latter, and as I have not unfrequently seen them hooked on in this position, I am inclined to consider them as connective structures.

Contractility and contractile textures of Tethea.—I have not had a sufficiently favourable opportunity of observing the contractility of Tethea. I have, however, no doubt whatever, from the recorded observations of Donati and of Audouin, and Milne Edwards, that these sponges are capable of slow but decided contractions and relaxations. In the outer part of the recently-formed rind the fleshy substance consists of a

slightly granular but transparent substance, in which are embedded numerous nucleated cells. These cells are generally acutely spindle-shaped, or split at one or both extremities. They are more abundant around the water-orifices, and are there intermixed with many *stellate* and *bi-stellate* silicious spicula.

The inner part of the rind is denser, and consists almost entirely of nucleated fibre-cells, which run more or less transversely, or across the axes of the spicula.

Similar fibre-cells are met with abundantly in the fleshy walls of the larger water-canals of their intermediate substance, along with *stellate* and *bi-stellate* silicious spicula.

The anatomical characters, arrangement, and relations of the fibre-cells of Tethea, taken along with the acknowledged contractility of the group, indicate the functions of the fibre-cells in the economy of these sponges. Their peculiar aspect, elongated form, transverse relation to the spicula, and grouping around the water-canals, appear to me to indicate very clearly their muscular character. I do not, however, conceive them to be the only contractile structures in the mass of the sponge; for I am inclined to believe that the slightly granular gelatinous matrix, in which they and the other structures are embedded, is also capable of a slow but decided change of form, like the mass of an amæba, or the peculiar texture with which observers are now familiar in so many of the lower organisms, and which has been termed by Dujardin, Sarcode.

The more energetic contractility of the fibre-cells would appear to be concentrated on the spicula and skeleton; the movements of the gelatinous matrix probably regulate the diameter and capacity of the water-canals.

Pores, Water-Passages, and Oscula.—The pores, or afferent water-orifices, are arranged in groups of three, each group in relation to a six-radiate spiculum, so that a pore is situated in each angle between the three primary branches of

the spiculum. As a result of this arrangement, it may be observed that when two or more of the six-radiate spicula are symmetrically arranged, each elongated octagonal mesh includes two pores—one at each of its extremities, and belonging to distinct groups or systems. Dr. Johnston has denied the existence of pores and oscula in *Tethea cranium.* I have, however, satisfied myself that pores of that sponge are situated in the furrows between the conical papillæ. Dr. Johnston's observations were made on a specimen preserved in spirits, with which I supplied him ; my own observations were made on similar specimens. Neither Prof. Ed. Forbes nor I could detect with the naked eye, or by means of lenses of low power, either pores or oscula in the living sponge examined in sea-water. But as the specimens had been for some hours out of the water, and were not examined after a sufficiently long interval of undisturbed repose, I am inclined to attribute our failure in detecting the contractility of Tethea, and also the pores and oscula, as had previously been done by Audouin and Milne Edwards, to the continued contraction produced by the disturbance of the animal.

I have not been able to detect in *T. cranium* any trace of oscula ; but if an inference may be drawn from their situation in other sponges, I would be inclined to look for them on the conical spicular elevations of the rind.

I have already referred the somewhat elevated spaces, bounded by the rectangular extremities of the six-radiate spicula, or the assumed corresponding dodecahedral spaces of this new species, to the conical spicular elevations of *T. cranium ;* I am therefore inclined to believe, that if oscula exist at all in the form now under consideration, they must be sought for in these spaces.

It is interesting, in connection with this question, to observe that the recent rents or fissures in the rind are generally margined by the denuded quadrangular extremities

of the six-radiate spicula, while the pores in their semi-octagonal recesses still remain entire; so that these fissures, and perforated grooves which result from them, may be considered as a linear arrangement of the spaces in which it may be inferred the oscula ought to develop. As an additional evidence in favour of the opinion I have already stated in reference to the position which the oscula of Tethea ought to occupy, I may refer to Mr. Huxley's recent account of an Australian species, in which he found irregular apertures or prominent tubercles on the surface. Now these could not have been pores, which he does not appear to have looked for. They must have been oscula; and their relations, as far as they are given, are in accordance with this supposition.

I have arrived at the conclusion, therefore, that there are afferent orifices or pores in *T. cranium*, and in the Tethea now under consideration, but efferent orifices or oscula exist in neither. How the water and animal *debris* escape from *T. cranium* I have not yet determined; but if I may hazard an opinion as to their mode of exit, it is that they pass off through the older and more open portions of the rind, where the central or radiating spicula are nearly laid bare, or have begun to project. Although the rind is continuous in *T. cranium*, it is never, as far as I am aware, uniform: the more recent portions are smooth, without projecting spicula or conical elevations; the portions of medium age present the characteristic conical projections; the more ancient portions are comparatively open and porous, the projections have disappeared, and the radiating spicula project. These more ancient portions of the rind of *T. cranium* correspond to the rindless portions of the surface of the Spitzbergen species. From these facts and considerations I have come to the conclusion, provisionally—1st, That neither *T. cranium* nor the Spitzbergen *T.* possesses efferent orifices properly so called;

2d, That in *T. cranium* the water and *debris* find an exit through the more ancient portions of the rind; 3d, That in the Spitzbergen species the water and *debris* pass off through the rents in the more recent portions of the surface—through the open parts of the surface where the rind is thin or deficient, but principally through the perforated grooves, which are in fact partially repaired fissures.

The pores of the Spitzbergen Tethea are the orifices of tubes which pass through the rind.

From what has been already stated, it will be perceived that these tubes are arranged in groups of three; the three tubes of each group being set around the shaft of the corresponding six-radiate spiculum, which is in fact the axis or skeleton of the group.

It must be recollected, however, that the branched heads of the six-radiate spicula are arranged at various depths in the rind; and as they always appear to embrace a water-tube in each of their primary angles, and are, besides, not placed perpendicularly under one another, so the tubes which proceed inwards from the primary angles of the superficial to the primary angles of the deeper spicula must be twisted or bent.

Whether the water-tubes of the rind ramify I have not been able hitherto to determine, but it appears to me probable that they do, because the six-radiate spicula are more numerous towards the surface of the rind than at its central aspect, and therefore the groups of water-tubes must be proportionally increased in number towards the periphery.

I have already stated that it appears to me highly probable that in the younger, and therefore more symmetrical form of this sponge, the six-radiate spicula of its rind are arranged in systems so as to include a dodecahedron in six octagons, that each octagon encloses a pair of pores, while the dodecahedron includes in its own share the terminal bundles of the intermediate portion of the skeleton, and is at the same

time the typical position of the oscule or feculent orifice of the system of sponge-groups by which it is surrounded. It therefore becomes a question, since the superficial spicula of the rind are not arranged perpendicularly above the deeper, what are their relations in this respect. I have not succeeded in determining any relation; but from what may be observed in the more symmetrically developed *T. cranium*, I am inclined to suspect that the successive strata of systems of spicula are so arranged that lines passing through their centres would be spiral.

The comparatively minute canals of the rind become larger as they pass into the intermediate or radiating masses of the sponge. They no longer retain the same fixed relations to the skeleton, but retiring from the immediate vicinity of the spicular fasciculi they pass inwards, frequently anastomosing in the interior of the intermediate spongy mass. The anastomoses become more frequent as the tubes approach the nucleus, in which they degenerate into areolæ.

The afferent water-canals are at first not to be distinguished from the more or less frequently anastomosing efferent tubes; but as they collect together into larger branches, and converge outwards and downwards to the equatorial region, and the attached polar region of the sponge, they become so much larger, and their aspect is so peculiar, that they at once catch the eye. Their walls are surrounded by, or rather consist of, a semi-transparent matter, consisting of the peculiar granular sarcode, intermixed with fibre-cells and stellate spicula already described. These efferent tubes all terminate at right angles or obliquely, mediately or immediately in the fissures or perforated grooves on the surface, and the abundant gelatinous material of their walls is continuous with the matter of the same kind which I have already described as filling up and repairing the recent fissures and reducing them to their perforated grooved form. The fissures result from the

internal development of the mass ; so that the efferent channels of this sponge are in fact mechanical openings—vents produced by its internal growth.

I have already described the textures which enter into the structure of the rind, and which line its water-tubes.

I have also stated that the same textures surround the afferent canals.

The perforated membrane of the grooves contains more abundant fibrous texture, and a greater number of stellate spicula.

The walls of the afferent water-canals in the intermediate masses are lined by minute bodies, which may be denominated sponge-particles. My specimens having been preserved in alcohol, I have been unable to detect on the sponge-particles the cilia which they present in the living Grantia,* and for the discovery of which we are indebted to Dr. Dobie and Mr. Bowerbank. I have no doubt, however, that these particles are covered with cilia, and that the currents through the canals are produced by their agency. The particles present the usual nucleus, cellular contents, and the clear space or contractile vesicle. They are from the 2000th to the 3000th of an inch in diameter.

In the intermediate masses of this sponge there are also to be met with very abundantly, but irregularly distributed, minute cellules about the 4000th of an inch diameter, many of them with tails or processes like spermatozoa, and occasionally exactly resembling spermatozoa. From a preserved specimen I cannot pretend to determine whether these minute bodies are the earlier forms of other sponge-particles, or whether they are actually spermatozoa.

Ova are also very abundant in the intermediate masses. When minute the ova exhibit a nucleus or germinal vesicle, but when larger they present the appearance of mulberries, or minute spherical botryoidal masses.

* See Goodsir's *Annals of Anatomy and Physiology*, pp. 127-129.—Eds.

Many of these masses appear to me to break up into the constituent elements of the intermediate masses of the sponge, while others near the denuded portion of the surface are arranged and developed into new rind. Some of these ova-like bodies have a distinct covering of silicious granules, and if we are to be guided by the analogy of Spongilla, they must be the sources of the ciliated or locomotive particles which, ejected from the parent, move off to become fixed and developed as independent individuals.

X.—ON AN UNDESCRIBED FORM OF GASTEROPOD MOLLUSK FROM THE FIRTH OF FORTH.*

After the severe storm which occurred in February 1855, two of my pupils, Messrs. Cleland and Bryden, applied to me for assistance in determining a number of animals which they had picked up on the beach opposite the Black Rocks at Leith. The collection, with one exception, consisted of ordinary forms. The peculiar specimen was a Gasteropod Mollusk, dead, apparently bleached, somewhat rubbed, and presenting the appearance of an Eolis deprived of its plumes. The novelty of its form was, however, specially evinced by the remarkable characters of its branchiæ, which consisted of a number of closely-arranged longitudinal laminæ, depending from the roofs of true crypts, situated one on each side of the body near the head, and opening out in the lateral grooves under the margins of the mantle.

The specimen was at once handed over to me, and on examination proved to be a new form closely allied to Diphyllidia.

The animal is white, inclining to pale citron, except the branchiæ, which are light brownish yellow.

The body is elongated, ovate, gradually acuminated posteriorly, and somewhat depressed. Its extreme length is $1\frac{1}{8}$ inch; its greatest breadth across the mantle $\frac{3}{8}$-inch.

The mantle is kite-shaped, its posterior angle reaching the

* This paper was written in the year 1855, and intended to be read before the Wernerian Society, which it was at that time proposed to reconstitute, but as this idea was not carried out the paper was never published.—Eds.

extremity of the body, and almost fusing into the corresponding apex of the foot. On its surface, at its lateral angles, are two circular convexities, which nearly meet in a depression at the middle line. These convexities are the vaulted roofs of the crypts which contain the branchiæ, the deeper colour of which appears through them. Behind the depression between the branchial convexities is a longitudinal elevation which tapers backward, is bounded laterally by two slight furrows, and is produced by the subjacent visceral mass. Beyond these furrows the margins project over the lateral grooves. The anterior margin of the mantle is convex, presenting at its centre a concave incision, where it is also elevated or tilted backwards. Behind the concave incision, and exactly repeating its curvature, a number of opaque, slightly-raised ridges extend across the mantle at equal distances, but becoming fainter, are lost as they reach the branchial elevations. Ten or twelve faint opaque white stripes, which become narrower and fainter as they pass back, diverge from the concave incision along the mantle over its elevations, and are lost about the middle of the back. These stripes are more distinct towards the middle line than at the margins of the mantle.

The foot corresponds in form with the body. It is somewhat narrower than the mantle; with which it is nearly in contact posteriorly, where the apices of the two structures appear to run into one another. It is transversely rugose; but smooth along both margins. A mesial furrow extends along its posterior third. In front its margin is concave, and in contact with the oval disk.

The mantle and foot, but particularly the former, are considerably broader than the body; so as to include between their projecting margins on each side a groove, the bottom of which is formed by the side of the body. The grooves are narrow behind, where they are terminated by the fusion of the

apices of the foot and mantle. They become wider as they extend forwards; and at the lateral angles of the mantle each divides into a notch-like furrow which separates the anterior lateral part of the pedal margin from the lower margin of the head-veil; and into a deeper furrow which extends across the back to become continuous with the corresponding furrow of the opposite side, and to separate the mantle and head-veil from one another.

The head presents in front and below an oval disk, which consists of a number of concentric fleshy folds, in contact posteriorly with the anterior marginal concavity of the foot. When the margins of a longitudinal slit, which is situated in the centre of the disk, are separated by a pair of needles, the dentated edges of a pair of hard dark-coloured horny lateral jaws are seen and felt. The oval disk is evidently the retracted condition of a short proboscis. The head-veil is crescentic. Its anterior convex margin is slightly fused at the middle line in front with the superior margin of the oval disk; while its posterior concave margin is elevated, opaque, and separated from the front of the mantle by the nuchal furrow. Its horns are directed downwards and backwards, and separate the divisions of the lateral grooves, as already stated. From each horn a ridge extends to its anterior margin. In texture and colour the head-veil resembles the mantle.

From the bottom of the nuchal furrow in front of the concave incision of the mantle, a semicircular fold rises so as to include a transversely oval pit. The middle of the fold is elevated into a lamina, which rises obliquely in front of the pit. In the pit itself are two rounded papillæ, and on the fore and outer part of each is a minute eye.

At the anterior extremity and widest part of each lateral groove, and immediately under each lateral angle of the mantle, there is a cavity which contains branchiæ. The cavity

opens by a wide orifice under the overhanging lateral angles of this mantle, which are slightly curled up or elevated. The cavities nearly meet from the opposite sides, and appear to be the real terminations in front of the lateral grooves. The bronchiæ consist of from twelve to fifteen laminæ, closely set together, extending from before backwards, longer internally in the cavity than externally, where they are small, short, and indistinct. The larger laminæ at the inner part of the series are attached to the vault of the cavity; the shorter, less distinct plates depend from the under surface of the projecting margin of the mantle. The laminæ are of a light brownish-yellow colour, and appear each to consist of a double membrane with a quarter lens; and under a favourable light, a number of faint opaque lines, each of which presents a few dots, apparently orifices, may be observed to be arranged on the under surface of the anterior half of the projecting margin of the mantle. Each line runs obliquely from behind forwards and inwards.

The common genital vestibule is situated in the right lateral groove, immediately behind and below the bronchial chamber. It is circular. From its anterior compartment an elongated male organ projects. Its posterior compartment presents the opening of the female organs.

The anus is situated on the apex of a cylindrical papilla, at the middle of the right lateral groove.

This animal is evidently an infero-branchiate mollusk. In the position of the anus, and in its characters generally, it closely resembles Diphyllidia, but differs from that genus in the arrangement of the branchiæ, which, instead of consisting of a series of oblique laminæ arranged along the two posterior thirds of each lateral groove, are in the form of transverse series of longitudinal laminæ depending from the roofs of the two lateral cavities. So very marked was the apparent difference between my specimen and the

descriptions and drawings of Diphyllidia, that I had no hesitation in referring it to a new genus, which I had proposed to denominate Cryptophylloma. Professors Jameson, Allman, and Huxley all agreed with me as to the novelty of the form. Within the last few days, however, I have again carefully examined the specimen, and have discovered the oblique dotted markings under the margin of the cloak.

I am now inclined to believe that it is merely a new species of Diphyllidia, with its posterior branchial laminæ removed or torn off. I am the more inclined to believe that this is the case from the examination of Mr. Albany Hancock's drawing in the first volume of Forbes and Hanley's *British Mollusca*, and from a reperusal of Otto's description (*D. liniata*) in the tenth volume of the *Nova Acta*. Otto states that " the branchiæ, where they terminate under the curved anterior border of the mantle, become suddenly broader, and form a process which passes into a hollow in the form of a blind sac, so that the right and left branchiæ nearly touch one another between the body and the mantle." If my supposition be correct, the existing descriptions of the branchiæ of Diphyllidia are insufficient. I have no doubt that each portion of the branchial laminæ in that genus will be found to depend obliquely from behind forwards and inwards from the lower surface of the free margin of the mantle, and that the anterior ones become crowded together as a transverse series of large longitudinal plates in the pit or crypt in which the lateral groove terminates under the lateral angle of the mantle. As I have only discovered the markings under the margin of the mantle within the last few days, I have not yet had time to communicate with Mr. Hancock. At a subsequent meeting of the Society I hope to be enabled to submit the result of additional inquiries regarding this form of mollusk.

XI.—ON THE NATURAL HISTORY AND ANATOMY OF THALASSEMA AND ECHIURUS. By Edward Forbes and John Goodsir.*

Among the Radiata of the British seas are two animals which, in their general appearance, rather resemble *Annelides* than *Echinodermata,* to which latter class they structurally belong. These are the *Thalassema neptuni* and *Echiurus vulgaris,* members of the family *Thalassemaceæ* in the order *Sipunculidæ,* a zoological and anatomical description of which species we have to-day the pleasure of submitting to the Wernerian Society.

The family *Thalassemaceæ* includes a group of vermigrade *Echinodermata,* characterised by having cylindrical worm-like bodies terminated at one extremity by a mouth, which is placed at the end of a short proboscis, to which is appended a remarkable sheath-like appendage, and at the other by an anus with no external appendages.

These characters distinguish it from the other families of its order ; from the *Sipunculaceæ,* which have a tentaculated trunk, no sheath-like appendage, and an anus placed at its base ; and from the *Priapulaceæ,* which have a trunk without tentacula, no oral appendage, and the anus at the posterior extremity at the end of a long filamentous caudal appendage, which has been regarded by some naturalists as a respiratory organ.

The genera *Thalassema, Echiurus, Bonnellia,* and *Sternaspis,*

* Read before the Wernerian Natural History Society on 23d January 1841.

constitute the family. The first has a simple oral appendage and no corneous bristles surrounding its anus ; the second has also a simple oral appendage, but has circles of corneous bristles or setæ surrounding the posterior extremity ; the third is distinguished by its forked oral appendage ; and the fourth is marked out from its allies by the possession of a corneous disk, surrounded by setæ placed near its anterior extremity. But few species are included in these four genera. Of *Thalassema* but one is known. Of *Echiurus* two have been described, the one a native of our own seas, the other of the North Pacific. Of *Bonnellia* two species are recorded, both inhabitants of the Mediterranean, as is also the only known species of *Sternaspis.*

The *Thalassema neptuni* is a native of the coast of Cornwall and Devon, where it lives among submarine rocks. Hence Lamarck, in the first sketch of his history of invertebrate animals, styled it *Thalassema rupium.* It was discovered by the observant Gaertner, and by him sent to Pallas under the name by which it is now known. Pallas, however, considered it an annelide, and an ally of the earthworm, and named it *Lumbricus thalassema,* under which name he describes and figures it in his *Spicilegia Zoologica.** Montagu afterwards found it and described it under the name of *Thalassina mutatoria.*† At the same time he expressed his belief that his animal was identical with that described by Pallas, but supposed that the figure given by that illustrious naturalist was incorrect. This, however, is not the case, the figure of Pallas well representing the animal after preservation in spirits, in which state doubtless he had only an opportunity of seeing it.

Of late it has been taken by Mr. Harvey at Teignmouth : from his specimen our structural account is drawn up. Of its external characters it need only be mentioned, additional to

* *Fasc.* x. t. 1. f. 6. † *Linnæan Trans.* vol. xi. p. 24, t. v. f. 2.

the descriptions of Pallas and Montagu, that it possesses a short retractile trunk, as well as an oral appendage. Montagu's account of its habits, when alive, is all we know of them, but is most full and interesting, and may be found in the eleventh volume of the *Linnæan Transactions.*

The *Echiurus vulgaris* is a much larger and more remarkable animal. A great number of individuals of this species were thrown up on the sandy shore of St. Andrews during last winter after a severe gale of wind. The largest specimens measured about six inches long and half-an-inch in diameter. The body of the creature is cylindrical, annulated with little flat tubercles, which were floccose towards the two extremities. From the anterior end projected a proboscis about half-an-inch in length, not furnished with tentacula, and having a deep red margin at the extremity. This proboscis is retractile, but not so a singular furrowed fleshy appendage placed alongside of it. This appendage is highly extensile, and forms a sort of sheath to the proboscis. A little way from its junction with the body are two shining yellow cartilaginous bristles; short, lanceolate, curved, acuminate, and retractile. These are the genital hooks. From between them runs a red line down the body towards the anus, marking the course of an internal vessel. The whole of the body is of a bright pink colour, with obscure paler narrow rings and speckles caused by the minute tubercles of the skin being of a paler hue. The anus is placed at the posterior extremity on a somewhat flattened disc, which is surrounded by two circles of corneous setæ, similar in structure to the genital hooks, but shorter. They are ten in number in each circle. The anus is round and red. The sheath of the proboscis differs in colour from the rest of the animal, being of a bright scarlet. It is so slightly affixed to the body as to break off on the least touch, and in only one or two cases did we find it attached, and then it broke away immediately on the removal of the animal.

On keeping the *Echiurus* alive in a vessel of sea-water, it was continually changing its form, swelling itself out in various parts so as to assume very strange and eccentric shapes. If a fresh supply of salt water was poured into the vessel, it would on a sudden become very vivacious, starting up towards the surface, and swimming with spiral contortions in the manner of an *annelide.* Then it would sink to the bottom of the vessel, and swell itself out with water.

The *Echiurus*, like the *Thalassema,* was first figured and described by Pallas, who obtained it from the coast of Belgium. He gave a most accurate general representation of it, but strangely omitted the true proboscis ; and by all writers since his time the sheath has been described as a proboscis not only in this case, but in the descriptions of most of the other *Thalassemaceæ.*

Montagu first perceived the true relation of the *Thalassema,* and remarks in his paper that it should immediately precede *Holothuria.* This view of its position was also held by Cuvier, and more lately by Brandt. Lamarck, however, placed the *Thalassema* and *Echiurus* in his first division of *annelides,* characterised by having no feet, and including the families *Hirudines* and *Echiureæ.* In the latter, associated with the earthworm and cirratulus, we find these animals before us. Many zoologists since his time have looked upon them as worms, but the structural details which follow will show that their relation to the annelides is one of analogy and not of affinity, and that their true position is among the *Echinodermata* in the order of *Vermigrada* or *Sipunculidæ.**

Echiurus—Digestive System.

The digestive tube commences by a mouth of a rounded form, very small in the state of contraction, funnel-shaped when dilated. The oral orifice is continuous with a canal

* See Forbes's *British Echinodermata.*

which is sacculated and contracted at intervals, particularly in its posterior half. This first portion of the intestinal apparatus, which may be denominated the pharynx, is arranged in two coils so as to resemble somewhat the figure 8. These coils are compressed and kept in position by the muscles of the oral hooks and by the blood-vessels, which assume a complicated arrangement in this part of the animal. The tube then contracts into a highly muscular but very narrow œsophagus. This rather suddenly dilates into the remaining part of the canal, which is nearly uniform in diameter, thin and delicate in texture; arranged in a somewhat spiral direction till near the posterior part of the animal, returning upon itself in the same manner for two-thirds of the length of the body, and then proceeding to the cloaca as a straight and rather narrow tube. The cloaca is smaller than the same organ in the *Holothuriadæ*. From mouth to anus the canal measures from three to four feet. The pharynx is two inches long, the œsophagus four, and the remainder is so uniform in diameter as to render it impossible to distinguish any division into stomach, intestines, etc., and so fragile as to render measurement very difficult. The pharynx exhibits distinct circular muscular fibres, and in the œsophagus they are so strong and so arranged in bundles as to give it the appearance of a windpipe. The tube is not connected to the parietes of the body by a mesentery, but by numerous delicate muscular threads irregularly arranged and intermingled with minute blood-vessels. Near the middle of the body the folds of intestines are filled with a yellow bilious mass, but we could detect no trace of a liver, or of glandular structure in the coats of the gut.

The respiratory sacs open into the cloaca on each side of the rectum. These sacs do not ramify, and are about one-third of the length of the animal, and exhibit in the living individual lively motions—contracting, dilating, elongating, and twisting. They are of a vivid red colour from the number of vessels dis-

tributed to them, and have a mottled appearance from numerous microscopic organs attached to their external surface. When a small portion of the respiratory organ is cut from the living animal and placed under the microscope in a little sea-water, the dots observed with the naked eye on its outer or peritoneal surface, exhibit the appearance of a number of funnels, with their necks attached, and their cup-like extremities standing erect. Each of these funnels has its outer surface, rim, and inner surface or cavity, covered with cilia which exhibit lively motions. The inner or mucous surface of the respiratory sac has a number of rounded somewhat lobulated elevations on it, each corresponding to one of the funnels on the outer surface. These elevations are covered with cilia, but on the membrane between them none could be seen. The ciliated funnels could be withdrawn into the pouches formed by the ciliated elevations of the internal surface ; but we could not obtain ocular demonstration of what we suspect to be the case—that the cavities of the funnels open into the common respiratory cavities, and that the ciliated elevations of the inner surface disappear when the funnels in the outer surface are extended ; and *vice versa*, a current being in this way established between the respiratory cavities and the common cavity of the body of the animal, which is full of sea-water. The muscular fibres of the two respiratory sacs exhibit a peculiar arrangement. Both the transverse and longitudinal fibres have an undulating course so as to surround the necks of each of the funnel-shaped organs as the fibres of the human gravid uterus surround the uterine sinuses. If the currents of sea-water flow through the funnels, the contraction of the muscular fibres can stop that flow, and enable the animal to fill the respiratory sacs by the following process. By contracting the anterior part of its body, and pushing the contained sea-water back, the animal distends its posterior portion into a bulbous shape, in consequence of which the

enclosed portions of the anal spines become widely separated; and from their connection with the cloaca that cavity is dilated, and, acting like a syringe, sucks in more water. The animal then closes the anus, and contracts the cloaca by pushing the water in its body forwards. This simultaneous action forces the water contained in the cloaca into the respiratory sacs, along which it is conveyed by their powerful vermicular or peristaltic action. A slight relaxation of the muscular fibres of the sacs, and the erection of the ciliated funnels, will allow the water to pass into the cavity of the body, while the action of the cilia will remove it through the same channels in a contrary direction.

The vascular system consists of two longitudinal vessels, one running along the ventral surface of the body, the other along the unattached surface of the intestine. The intestinal trunk is always full of blood in the weak or dead animal, the ventral trunk always empty or collapsed. From this circumstance, from the general arrangement of the vascular system, and from the position of the respiratory organs, we are inclined to think, although we have not been able to verify the opinion by actual observation, that the former vessel is the venous, the latter the arterial trunk. The vein commences by numerous radicles on the œsophageal portion of the digestive tube, runs along the edges of the gut, collecting branches as it proceeds. On the rectum, the trunk disappears by being divided into innumerable branches, which are apparently arterial, and proceed to the respiratory sacs, which, as before stated, are highly vascular. The arterial or ventral vessel is apparently formed by radicles from the respiratory sacs (branchial veins). Its walls are thin, and are perceived with difficulty on the surface of the nervous cord. In its course it supplies vessels to the intestines; and when it arrives at the convolutions of the pharynx, it sends off from its right side a large trunk, which, proceeding to the right oral hook,

surrounds it and its muscles by dividing and again closing. It then proceeds to the commencement of the œsophagus, and joins a vessel to be described immediately. The ventral vessel, after giving off this great trunk, proceeds to the oral extremity of the pharynx, round which it forms a vascular circle. The latter sends branches back upon the pharynx; and a branch forwards, which forms a second circle or vascular zone round the lip, on the surface of the nervous ring, and a large trunk which, running to the middle of the pharynx, dilates into a sacculated sinus, which probably owes its peculiar appearance to the transverse contractions into which this portion of the tube is generally thrown. This sinus runs along the second portion of the pharynx, and at the commencement of the œsophagus receives the trunk formerly described as proceeding from the ventral vessel. It then terminates by ramifying on the œsophagus, and supplying this portion of the tube with aërated blood. The use of the large trunk which comes off from the ventral vessel, is evidently to supply the mouth, trunk, and anterior part of the digestive tube, with arterial blood, when the animal has projected the anterior part of the body, and when the constriction of the snout, and the pressure of the sand in which it is boring, would prevent the free circulation of the blood in the two vascular circles, at times when the supply is absolutely necessary from increased muscular action.

The nervous system is very simple, being merely a ring surrounding the anterior part of the pharynx when it becomes continuous with the skin. From this ring a nervous cord runs along the under side of the animal to the extremity of the body, terminating abruptly by sending off a few branches. Along its course the cord gives off numerous lateral twigs, which are unsymmetrical, and continue free for a short distance from their origin, and then disappear in the muscular parietes of the body. When the animal is contracted, the

cord is arranged in close undulations, and exhibits no ganglionic enlargements. It consists of a moderately long sheath, in which the nervous matter is contained in a very soft condition.

The reproductive system consists of four sacs which open on the ventral surface by minute orifices, two immediately behind the genital hooks, the other two about an inch farther back, and both pairs about one-third of an inch from the median line. When the *Echiurus* is not in season, they are about one inch and a half long, one-fourth of an inch in diameter, highly transparent, so as to be almost invisible, and possessed of the power of twisting in all directions. When the male is in season they become greatly enlarged, four inches long, half-an-inch in diameter, with one or two contracted portions. The contained fluid is milk-white, and rather consistent; and when examined under a high power, it is seen to swarm with exceedingly active globular *spermatozoa*, which exhibit rapid whirling and dancing motions. The male organs, when in this condition, are remarkably beautiful objects, being covered with large thread-like and transparent scarlet blood-vessels, which are relieved by the dead cream-white of the organs themselves. We have not seen the female sacs fully distended; when moderately so, the eggs appear to be arranged as in the roe of osseous fishes, and are about the size of millet-seed. Examined under the microscope, the egg appears as a highly-transparent globule, enclosing towards its centre a number of smaller globules or cells.

The structure of *Thalassema neptuni* is in all respects identical with *Echiurus*, the only difference, and that an unimportant one, being the less complicated arrangement of the intestinal tube.

The oral and anal hooks and spines of *Echiurus*, and the oral hooks of the *Thalassema*, are protruded and withdrawn exactly as the setæ and hooklets among the *Annelides*.

From the anatomical description we have now given, it is evident that the genera *Echiurus* and *Thalassema* must be arranged in the class *Echinodermata.* The body filled with sea-water—the respiratory apparatus—the digestive system—and the intestinal venous trunk, are the leading anatomical peculiarities, and are characteristic of the echinodermatous animals. The colour and circulation of the blood, the want of an aquiferous system, the ventral nervous cord, and the muscular system, show the relation of these animals to the *Annelides,* and prove that the transition from a vermiform radiate animal to a true articulate animal, is effected by the symmetrical atrophy and hypertrophy of certain of the radiate elements in each ring.

XII.—ON PELONAIA, A NEW GENUS OF TUNICATED MOLLUSKS, WITH DESCRIPTION OF TWO SPECIES. By Edward Forbes and John Goodsir.*

Among the Ascidian Mollusca which we have collected together, with a view to a complete investigation of the British Tunicata, are two remarkable animals, which appear to represent a very natural genus as yet unrecorded. They differ from their allies in the tribe chiefly by their not being fixed, and by their form, which reminds one more of that of a Sipunculus than of an Ascidia ; indeed they may be regarded as analogues of certain Sipunculidæ, and in that point of view the details of their forms and structure are of much interest to the naturalist.

They are both of a cylindrical shape, having their orifices on the same plane, elevated on papillose eminences at one extremity of the body. No rays or tentacula surround either of the orifices. The posterior extremity of each terminates in a blunt point. They live buried in mud, quite unattached to any other body, and are extremely apathetic animals, presenting scarcely any appearance of motion.

We have styled the genus *Pelonaia* (πηλὸς, ναίω), and define it as follows :—

Test, cylindrical, unattached.

Orifices, without rays, or two equal approximated papillose eminences at the anterior extremity.

Species 1. *P. corrugata.* *Test, deep brown, much elongated, rudely wrinkled transversely.*

* Read before the Wernerian Natural History Society, April 17, 1841.

In the mud-filled cavities of old shells from deep water—Anstruther. It has also been taken by Dr. Johnston at Berwick.

Species 2. *P. glabra.* *Test, greenish-yellow, smooth, pilose, not nearly so much elongated as the last.*

Dredged in seven fathoms water, in mud, Rothesay Bay.

Anatomy of P. glabra.

1. *Muscular System.*—The mantle is similar to those of the other *Ascidiæ*, possessing longitudinal and circular fibres. A strong band of transverse fibres passes round the mantle, immediately below the anal orifice, encroaching on the cavity principally on that side. The chief peculiarity of the mantle is its firm adhesion to the test.

2. *Digestive and Respiratory Systems.*—The respiratory opening is of small size, and exhibits no folds or tentacular fringes. The respiratory sac is elongated, cylindrical, contracting rather suddenly towards one side to become continuous with the œsophagus. On the external surface of the sac there are about thirty parallel transverse ridges, which give it the appearance of a plaited frill. These plaits are less apparent along the course of the branchial artery and branchial vein, but midway between them on each side they are very prominent, and are tied each by a minute cord to the inner surface of the mantle. The internal surface of the sac exhibits along one side the serpentine double cord which contains the branchial vein; along the other side the branchial artery; and from these primary and secondary perpendicular branches proceeding, as in the other *Ascidiæ*. The transverse plaits on the external surface of the sac correspond to the primary or transverse branches of the vessels on the internal surface. The animal was not examined when alive, but cilia without doubt exist in great abundance on the edges of the lozenge-shaped spaces of the sac.

The œsophagus commences by a white plicated opening at the lower end, and on one side of the sac. It is curved in a sigmoidal form, and exhibits longitudinal rugæ through its coats. Near the lower end of the mantle cavity, it terminates by suddenly dilating into the stomach, which is pear-shaped, and directed obliquely upwards towards the side opposite to the œsophagus. The internal surface of the stomach presents longitudinal plicæ, and is succeeded by the intestine, which at first curves upwards, then down to the bottom of the mantle cavity, up along the œsophageal side of that cavity, and between its walls and the branchial artery, terminating about the anterior third of the animal in a funnel-shaped anus, which is cut into ten or eleven processes like the petals of a flower. The first part of the intestine is white and longitudinally plicated; the rectum is dilated with attenuated coats.

3. *Vascular System.*—The vascular system resembles that of the true *Ascidiæ*, except that there is no heart. It consists of two sets of vessels, with four sets of capillaries, a circle in fact twice interrupted, once in the respiratory sac, and again throughout the body. The branchial veins run along the transverse plaits of the sac, receiving secondary and ternary twigs at right angles. The primary branchial venous branches empty themselves on each side into the branchial venous trunk, which runs in the substance of the double cord which coasts the superior aspect of the sac. This double cord terminates in an abrupt manner anteriorly near the oral orifice, and in a similar manner, but after becoming smaller, near the orifice leading to the œsophagus. At this point the vein becomes an artery, and probably sends back vessels to nourish the sac. It now runs along the œsophagus, supplying the stomach and intestine, and giving off in its course branches to the cloak. The veins arising from the arterial capillaries of the body meet near the commencement of the œsophagus in one trunk, which, passing along the inferior wall of the re-

spiratory sac, opposite to the branchial vein, performs the function of a branchial artery.

It is interesting to observe here the differences between the modes in which the branches enter the branchial vein, and strike off from the branchial artery. In the former, just before the branches enter the trunk, they give off a number of vessels, which enter the trunk alongside of their parent trunk—the combination forming a sort of delta : in the latter they leave the trunk singly, and send off their branches in a radiating direction. At a little distance from the trunks of both artery and vein, the secondary branches become parallel to one another, and perpendicular to their primary branches, the more minute divisions following the same mode of ramification.

Not having examined the animal when alive, we have no information as to the nature of its blood.

4. *Nervous System.*—This system consists, as in other *Ascidiæ*, of a ganglion situated in the substance of the mantle, between the oral and anal orifices. It is globular, and sends off nervous twigs—1. To the respiratory orifice of the mantle, 2. To the respiratory sac, where it begins to exhibit the transverse plaits, and 3. To the anal orifice of the mantle.

5. *Generative System.*—The generative organs consist of two elongated tubes, closed at one end, open at the other, and having a great number of close-set parallel cæca, arranged at right angles, and opening into them along each side. These tubes are attached to the internal surface of the mantle, their mouths free for a short distance, and prominent, the rest of their extent and the attached cæca adherent. The orifices of these organs are situate at the junction of the first with the second quarter of the animal, and one-third of the other end of each turns in towards its neighbour, and then proceeds forward parallel to itself. The branchial vein runs midway between the generative tubes, above, and the bran-

chial artery in a corresponding course below, so that the threads of attachment of the plaits on the external surface of the sac are fixed into the tubes, in a series on each side.

*Anatomy of P. corrugata.**

The structure of this species differs very little from that of the *P. glabra.* The animal being elongated, the organs are placed more longitudinally. The respiratory sac is longer, the stomach is longer, and is not placed so much across the body. The œsophagus runs down to the bottom of the sac before it terminates. The rectum is very long, and of considerable width, but just before it terminates in the anus, it becomes very much contracted. The mantle exhibits no ridge or shelf below the anal orifice, but its longitudinal fibres are very strong, and form a thick bundle at their origin round the respiratory opening. The test, instead of being thin and diaphanous like parchment, as in *P. glabra,* is thick, cartilaginous in appearance, coloured brown, and transversely wrinkled externally.

From the details of structure which we have now given, it is evident that the *Pelonaiæ* are *Ascidiæ.* Their anatomy is important, as it explains the nature of the parts and organs in the *Tunicata.* They differ from the other *Ascidiæ* more particularly in being bilateral. The generative organs are symmetrical, and open one on each side of the anus, which is directed towards the ventral surface of the animal, in a line with the mouth and nervous ganglion. The latter is thus proved to be an abdominal or sub-œsophageal ganglion, corresponding to, or forming one of the chains of ganglia on the abdominal surface of, the articulata. In the same manner the branchial artery or heart is proved to be the pulsating

* Additional details, with some modifications in the description, have recently been given by Dr. W. C. M'Intosh, in the *Annals of Natural History,* June 1867.—Eds.

dorsal vessel, and the branchial vein the abdominal vessel (when that vessel exists) in the annulosa. It is interesting also to perceive that, co-existing with this decided approach to the annular type of form, we have the transverse plaits of the respiratory sac corresponding to the rings of an articulated animal. The disappearance of a separate test is also a departure from the plan of formation in the *Ascidiæ*, and an approach to other types of form, and more particularly to the *Cirrograde Echinodermata*, with certain of which *Pelonaia* has at least an analogical relation, in the water-filled body, and in the external form.

Pelonaia, in fine, is one of those connecting genera so valuable as filling up gaps in the system, and supplying links in the chain of structures, which runs through the series of organised bodies.

APPENDIX.

APPENDIX.

I.—ON ASYNCHRONISM OF THE AURICULAR CONTRACTIONS IN THE REPTILIAN HEART.—May 14, 1859.

Having occasion, in the beginning of August last, to inject the arterial system of *Scincus variegatus*, I laid bare the heart to empty the vessels by bleeding. I was astonished to observe what appeared to be a want of synchronism in the movements of the auricles. After a little observation, I was compelled to admit that the two auricles did not contract synchronously, but that after the ventricular diastole the right auricle began to contract, followed by the left. I also observed that the contraction of the ventricle began at its right side, in the neighbourhood of the pulmonary artery, and terminated on the left or arterial sinus of the ventricle. I now looked at Brücke's memoir in the *Vienna Transactions*, and found that he had described a ventricular arrangement by which venous blood only passes into the pulmonary artery in reptiles, that the ventricle begins to contract on its right side, and afterwards on its left. He takes no notice of any want of synchronism in the auricular contractions.

Messrs. Arthur and Stirling confirmed the observation on the lizard, and were also inclined, along with me, to admit a somewhat similar asynchronance in the auricular contraction in the frog, although I knew of no arrangement by which this co-operates in the sole transmission of venous blood to the lungs.

I exposed yesterday the heart of a tortoise, by removing four portions of the plastron with a trephine, in the presence of Mr. Turner. The asynchronism of the auricles did not appear to me so well marked as in the lizard. Mr. Turner scarcely admitted its

existence, but latterly expressed his opinion that the contraction of the right auricle terminated before that of the left. The contraction of the ventricle appeared to both of us to commence on the right side, and to be followed up by that of the left side. The close of ventricular contraction, or the commencement of diastole, was accompanied by a depression of the anterior wall of the ventricle towards its right side.

The distension of the pulmonary artery followed the contraction of the right side of the ventricle, that of the anterior aorta appeared to follow the contraction of the left side of the ventricle ; but this appearance depends probably on the earlier closure of the orifice of the pulmonary artery, and the continued distension of the systemic arteries.

I attribute the less marked asynchronism of the auricular contraction in this animal partly to the small amount of its blood from winter fast, partly to the interventricular septum being less developed than in the lizard.

I found that by turning up the ventricle by the handle of a scalpel, the prior contraction of the right auricle was quite distinct. It commences at the venous or vestibular extremity, and extends forward to the apex of the auricle. After the commencement of contraction in the right auricle that of the left begins, but the contraction of the right ceases before that of the left. I requested Mr. Turner to examine the movements in this manner, and he at once detected the prior contraction of the right auricle.

It appears to me that the blood of the right auricle diffuses itself over the anterior or inferior part of the ventricle, for the whole of this surface possesses a dark tint during distension. On the back or upper surface, again, the dark tint is confined to the right side, no doubt in consequence of the blood of the left auricle preoccupying that compartment.

We must assume that after the ventricular systole, and until the auricular blood enters, the muscular fibres remain unelongated. The ventricular compartments must therefore be nearly obliterated (see sections of contracted ventricle of turtle in museum), and the blood from the auricles must pass through the ventricle in the direction of least resistance. Now, as the right auricle contracts first, the venous blood passing out of it is directed obliquely into

the left side of the ventricle, under the fleshy ridge which projects from the superior wall and base into the compartment from which issue the two aortæ, and with which the pulmonary compartment communicates. It passes, however, under the fleshy ridge or septum (septum between venous and arterial ventricular compartments) towards the arterial compartment into which the blood of the left auricle begins to pass, a little later than that of the right into the right compartment. The passage of the venous blood from right to left is impeded by the spongy arrangement of the anterior or under part of the ventricle. In consequence, therefore, of *first*, the prior entrance of the venous blood, and of the course of least resistance into the venous compartment of the ventricle given it by the arrangement of the right auriculo-ventricular valve; *second*, the secondary entrance of the arterial blood of the left auricle, and its course of least resistance given by the left auriculo-ventricular valve; and, *third*, the retardation of the passage of the venous blood to the left side by the spongy texture; time is afforded for a sufficient quantity of mixed venous blood passing into the pulmonary artery by the prior contraction of the right side of the ventricle. After the closure of the pulmonary compartment and its complete contraction, the pulmonary artery begins to react, while the left side of the ventricle continuing to contract, black blood continues to flow as it did from the first into the aorta, but with more admixture of arterial blood, until the last blood, perhaps entirely arterial, alone passes through them.

May 18.—I removed by means of a trephine a circle of bone over the pericardium of a small tortoise of the same species. The small size of the heart enabled me and John Arthur to discriminate very distinctly the prior or initial contraction of the right auricle, and also the commencement of ventricular contraction in the right side, its longer continuance on the left. The portion of the ventricle which continues longest to contract is the left angle of the ventricle, which receives the blood of the left auricle, as shown by the scarlet tint of both. The black blood of the right auricle was seen, on entering the ventricle, to occupy in the first place the right side of the cavity, and then to disperse itself towards the left, on the sternal wall of the chamber, the posterior part of the left side of the chamber being occupied by red blood.

II.—NOTES ON THE MYOLOGY OF THE ELEPHANT.
May 1856.

The *Panniculus carnosus* consists of four portions—1st, *cervical*, ribbon-shaped, which arises from the forepart of the process of the scapular spine, and passes upwards and forwards; 2d, *dorsal*, arises from the elastic fascia on the back about a foot from the mesial line, and from along the posterior margin of the thorax: half-way down, its fibres converging are inserted by a thin tendon to the spine of the scapula; 3d, *thoracic*, from the remaining part of the margin of the thorax, with an edge below: its fibres converge to within the arm; 4th, a portion which arises from the line of origin of the last and below it, converges backwards to a strong tendon which spreads over the patella, and under cover of the strong fascia of the outside of the thigh.

The fascia of the posterior limb is exceedingly strong and appears to be continuous with the fascia of the trunk with which the *Panniculus carnosus* is also continuous. On the back and side of the belly it consists almost entirely of yellow texture, except in the middle of the back, the fibres pass upwards and backwards. Along the outer side of the thigh it is very thick and yellow from the spine of the ilium to the outside of the knee; over the latter it becomes white and envelopes the patella and joint, passing downwards, backwards, and inwards.

In the anterior limb the subcutaneous areolar tissue is remarkably dense, and presents the appearance of a close mesh-work of fibrous bundles without fat. The aponeurosis commences on the outer side of the limb in the line of the spine of the scapula and point of the shoulder, attached to the former, and lost above the latter on the surface of the anterior spinatus muscle; at the lower part of the bend of the elbow, and downwards to the carcase, it becomes thick, longitudinally fasciculated, and almost entirely composed of elastic tissue; on the outer part of the shoulder it is merely fibrous but strong; also over the triceps it is aponeurotic and comparatively thin; over the olecranon it has a similar appearance, but on the back of the arm it is again elastic though thin; below the carcase it degenerates into dense areolar tissue or fascia,

which covers the flexor and extensor tendons, passing into the pad of the sole and forming a thick elastic cushion at the back part or heel of the foot.

Subscapularis arises on the greater part of the costal surface of the scapula, comparatively thin and weak, inserted to the internal tubercle of the humerus. The superior anterior angle of the costal surface of the scapula, where it forms a thick surface, is occupied by the attachment of the serratus magnus, it also extends down over a considerable extent of the vertebral margin of the bone.

The *latissimus dorsi* in passing forward to the humerus is extensively connected to the posterior inferior part of the same margin, and lays hold by a strong aponeurosis to the corresponding surface of the subscapularis.

Coraco brachialis, attached above to the coracoid tubercle, has its tendon firmly attached to the inner surface of the tendon of insertion of the subscapularis, and is inserted into the whole length of the inner ridge of the humerus, as far down as the internal condyle: its tendon of origin passing down almost to its lower end, and the muscular fasciculi numerous, short, and oblique.

Triceps extensor consists of five heads; the inner head is small, and arises from the inner head of the humerus as far down as the condyle; the scapular head is of enormous size, and arises from the whole extent of the posterior margin of the bone; there is added to this scapular head a flat mass or head, which arises along with it from the posterior part of the margin, and extends down altogether independently to the inner side of the olecranon. The outer head is massive, and arises from the outer and back part of the humerus as far down as the great external tuberosity of the bone; from this external tuberosity a small but distinct fifth head arises. The larger and smaller external, internal, and the scapular heads, are inserted by a common tendon into the olecranon, but the narrow head which arises along with the scapular has a distinct tendon to the inner side of the olecranon.

Flexor carpi radialis, from the centre tubercle of the internal condyle, fusiform, except in the central part of its posterior surface, between its two tendons consists of elastic tissue; distal tendon

passes under annular ligament in a sheath ; appears to be attached to two metacarpal bones.

Palmaris longus, from the posterior margin of the internal condyle, along with the deep and superficial common flexors, passes under the superficial part of the annular ligament in the direction of the pisiform bone ; expands into the palmar fascia.

Flexor digitorum sublimis, from posterior margin of the internal condyle with the *palmaris longus* and *flexor profundus*, by a perfectly distinct head from the upper two-thirds of the inner margin of the olecranon, and from the corresponding part of its anterior surface ; this head joins the other head of the muscle about one-third down the forearm. At the same level the common mass of the *flexor sublimis* becomes detached from the palmaris longus and flexor profundus, passes down to the carpus under the annular ligament, with which its lower tendon is intimately connected.

Flexor d. profundus, considerably more massive than the f. sublimis, arises altogether from the internal condyle (its posterior part and inner margin) ; it passes down, covered by palm. longus and flexor sublimis, and underneath the annular ligament and tendon of the superficial flexor.

Flexor longus pollicis arises from the internal condyle, anterior and inferior to the *flexor profundus*, terminates in a delicate tendon at the lower third of the arm which passes underneath the annular ligament along with the tendons of the other flexors.

Flexor carpi ulnaris arises from the inner, lower, and back part of the surface of the olecranon, as a small conical muscle which terminates in a cord-like tendon at the upper part of the arm, and which passes down towards the pisiform bone under the deep flexors of the fingers. The elongated pisiform bone, which passes considerably inwards towards the annular ligament, co-operates with the latter in forming the tendinous retinaculum.

Anconeus, from the lower two-thirds of the posterior surface of the elongated external condyle of the humerus, and separated by a deep intermuscular space from the smaller external head of the triceps. The fibres extend downwards, curving forwards, to be attached to the whole external surface of the olecranon and the external surface of the ulna half-way down. Some of the fibres curve to the posterior aspect of the bone.

Extensor carpi ulnaris arises by a small but strong tendon from the external part of external condyle of the humerus, is massive and fusiform, and passes under a tendinous arch from the back part of the lower end of the ulna in a shallow groove. The tendon then passes down on the inner edge of the foot to be attached to the head of the metacarpal bone of the fifth toe; it is crossed over near its insertion by the tendon of the *ext. min. digiti.*

Extensor minimi digiti is a cylindrical muscle closely bound down by an aponeurotic sheath to the ridge between the outer and anterior surface of the ulna. Above, it arises from the fore part of the external condyle, but almost all the way down it is attached to the ulna by means of its aponeurotic sheath. It continues fleshy down to the wrist-joint, and is tied down by the annular ligament in the shallow groove in front of the lower end of the bone. It changes its direction beyond the annular ligament, inwards and backwards, crossing the tendon of the last muscle, and is inserted into the upper and inner part of the metacarpal bone of the fifth toe.

Extensor digitorum communis.—In connection with the origin of this muscle is a very thick intermuscular septum, which is attached all along the edge which separates the inner from the anterior surfaces of the ulna, and separates the last muscle from the common extensor. This septum is attached superiorly to the external condyle of the humerus by means of an excessively strong portion of the common investing aponeurosis of the forearm. This portion of the aponeurosis forms a band consisting principally of elastic fibre of a yellow colour, and fully an inch thick at the lower part of its extent ; it splits into two portions, which are attached to the margins of the groove to which the tendon of the last muscle passes. The muscle itself arises from the deep surface of nearly the upper half of this band ; it is aponeurotic where the muscle arises from it, but entirely elastic in its texture below ; its fibres superiorly arise from the external condyle of the humerus, rapidly converge to form a massive conical compressed double penniform muscle, which terminates a little above the carpus in numerous laterally-connected tendons, which are arranged in the form of a flattened ribbon in a shallow groove on the lower and fore part of the ulna, tied down by the transverse ligament, and with an extensive synovial apparatus

upon the front of the carpus. This ribbon divides into *three portions;* the small internal one, passing down to the inner edge of the foot, divides into two slips, one for the fourth, the other for the fifth digits ; it is connected by a transverse slip to the middle division ; the middle division reunites along the metatarsal region with the external division ; they separate again at the base of the first phalanges—the middle division passing on to the third toe, the external division dividing between the first and second toes.

Extensor primi et secundi digitorum arises from the articular surface of the ulna over a narrow space or line about its middle, and, under cover of the common extensor, comes out from beneath it, and is tied down by the annular ligament near the transverse ligament on its outer side ; continuing fleshy beyond the ligament, terminates in a small tendon, which, splitting at its extremity, is attached to the phalanges of the first and second toes.

Extensor ossis metacarpi pollicis.—A fleshy mass arising from the anterior surface of the ulna along with the last muscle, but principally from the front of the radius. From its head downwards to its lower fifth its fibres are oblique, terminate in a strong tendon on its outer edge, and continue with the tendon down to the annular ligament, by which it is tied down in the hollow on the outer edge and back part of the radius. Its tendon, thick like a rope above, flattens out below, doubles upon itself, so as to form two laminæ, which are inserted continuously to the metacarpal bone of the first toe.

Extensor carpi radialis longus arises from the humerus by a small origin in front, and to the outer side of the rough impression of the centre of its anterior ridge. This is a comparatively small elongated muscle, intimately attached about its middle to the thick portion of the aponeurosis of the arm, to which the cervico-humeral muscle is attached. The muscle itself forms the anterior margin of the anterior muscular prominence between the upper arm and forearm, and, extending downwards, terminates in a rope-like tendon, which is crossed obliquely by the tendon of the extensor ossis metacarpi pollicis, and is tied down in a sheath formed by the annular ligament in a groove on the fore-part of the outer surface of the radius, and is inserted into the front of the scaphoid bone.

Extensor carpi radialis brevis.—A much more massive muscle of a flattened conical form, which arises from the external ridge of the humerus above the external condyle in contact with the last muscle. It extends down, and transmits its large rope-like tendon under the extensor ossis metacarpi pollicis, and under the annular ligament, which ties it down in the same osseous groove, but in a distinct sheath from the extensor longus. The tendon, flattening out, extends obliquely down the carpus and metacarpus, to be inserted into the base of the metacarpal bone of the third toe.

III.—NOTES ON THE GENERAL MORPHOLOGY OF THE MUSCLES.—January 1857.

The muscular, like the osseous system, is segmented.

This is proved—firstly, from embryology ; and, secondly, from comparative anatomy.

The primordial transversely-segmented myome, with its longitudinally-arranged muscular fasciculi, is converted during development into a complex system of longitudinal, oblique, and transverse muscles.

The morphological divisions of the muscular system by Professor Johannes Müller are—

1. Trunk lateral muscles, which in man are represented by the muscles of the dorsal region.
2. Intercostal muscles.
3. Abdominal muscles.
4. Muscles of limbs.

Müller's system is morphologically insufficient, inasmuch as it only admits the lateral trunk muscles as homologous with the primordial muscular arrangement (or rather with the upper half), while it would appear to indicate the other divisions as superadded or teleological.

The primary subdivisions of the muscular system appear to me to be—

1. A layer on the inner aspect of the hæmal chamber.
2. A layer on the exterior of the sclerome.
3. The muscles of the limbs, which, however, are merely modi-

fied portions of the two first divisions, but principally of the second.

Thus the first division consists of—

a. A layer lining the hæmal arches.

b. Pre-vertebral muscles.

c. Such pre-vertebral muscles as are attached to the limbs.

The second division consists of—

a. Muscles of so-called dorsal group.

b. Intercostal muscles.

c. Recti abdominis.

d. External and internal oblique muscles.

e. All the muscles of the limbs, except those derived from the first division.

f. Cutaneous muscles.

The third division therefore, although apparently distinct, and conveniently considered as such, is in fact derived from the first and second divisions.

IV.—NOTES ON THE MORPHOLOGY OF THE MUSCLES OF THE LIMBS.—June 15, 1858.

If the human femur and humerus be compared together, as observed from the front of each, it will be perceived, that while the surface of attachment of the brachialis anticus extends from the outer to the inner humeral ridges, up as far as the lower part of the insertion of the deltoid, inclosing the attachment of that muscle by its bifurcation, the surface of attachment of the homologous muscle in the thigh extends from each lip of the linea aspera and as far up as the intertrochanteric ridge. From this enormous extension of that muscular mass, termed vastus externus, vastus internus, and crureus, the homologue of the brachialis anticus, all the other muscles attached to the thigh-bone are attached to its trochanters and condyles, and to the space enclosed between the lips of the linea aspera. The comparison, therefore, of the characteristic configuration of the humerus and femur, or, in other words, the serial homology of their processes, surfaces, and edges, must be determined by a careful comparison of the corresponding or homologous mus-

cular attachments. The homology of these two muscular masses affords a key, not only to the general muscular homologies of the arm and thigh, but also to the corresponding osseous homologies.

The iliacus internus and psoas magnus are attached together into the trochanter minor. Of these two muscles the iliacus internus has been hitherto considered by the few anatomists who have directed their attention to this subject, as the homologue of the subscapularis ; but it has never apparently been taken into consideration, that whereas the subscapularis passes from the scapula to the humerus, under and behind both the clavicle and the coracoid, the iliacus internus and psoas magnus pass from the ilium to the femur in front of and above the pubis and ischium, the homologues of the clavicle and coracoid.

The iliacus internus cannot therefore be the homologue of the subscapularis. It will be observed, that if the brachialis anticus were to mount upwards, on the front of the humerus, to the region of its tuberosities, and to force its margins backwards until they nearly met on the back of the shaft of the bone, it would force the humeral attachment of the deltoid upwards and inwards, so that it would assume a position on the humerus corresponding to that of the trochanter minor and the thigh-bone. The outer surface of the ilium gives attachment to a pair of muscles—the gluteus medius and minimus—which are the homologues of the inferior spinatus and teres minor muscles ; the internal surface gives attachment below to the obturator internus, which is the homologue of the subscapularis ; the anterior surface, which gives attachment to the iliacus internus, must therefore correspond to that portion of the scapula intermediate between the subscapular fossa and the inferior spinatus at the cervical margin of the bone. The muscle, therefore, arising from the surface, must be either the homologue of the supra-spinatus muscles, or the scapular portion of the deltoid.

But as the supra-spinatus muscle is attached along with the infra-spinatus and teres minor to the trochanter major while the scapular portion of the deltoid is attached to the deltoid surface, which again is continuous with the great tuberosity by the anterior margin of the bicipital groove ; and as we have already seen that this deltoid surface would be forced upwards and inwards, and backwards, into the position of the lesser trochanter of the femur,

if the brachialis anticus were developed to the same extent as the vasti and crureus; the iliacus internus, in its origin, attachment, and relations to the pubes, exactly corresponds in its relations to those of the scapular portion of deltoid, if the bones of the shoulder were made to assume the relative positions of those of the pelvis. The homologue of the posterior margin of the spine of the scapula, widened and hollowed out, forms, in this manner, the anterior surface of the iliac bone, and the homologue of the scapular portion of the deltoid passes forward over and in front of the homologue of the clavicle.

With reference to the homologue of the psoas in the shoulder, it will at once suggest itself to the comparative anatomist, that the psoas is represented by the levator humeri, more particularly by that portion of it which is connected to the transverse processes of the cervical vertebræ. In the feline Carnivora the levator humeri passes down, in connection with the scapular portion of the deltoid, in front of the clavicle, and reproduces in this manner an arrangement in the shoulder exactly similar to that of the psoas, iliacus, and pubis, in the posterior limb. It is also to be observed, that the breadth of the anterior surface of the ilium is, in the greater number of Mammalia, diminished so much as frequently to present the form of a margin, while in the bird it has disappeared altogether, as well as the muscle to which it gives origin.

If the iliacus internus be the homologue of the scapular portion of the deltoid, then we are at once led to the homology between the pectineus and adductor longus in the posterior limb, and the clavicular portion of the deltoid, and the clavicular portion of the great pectoral in the anterior limb.

The pectineus and the adductor longus pass from the pelvic representative of the clavicle to the line leading down from the lesser trochanter; that is, from the attachment of the homologue of the scapular portion of the deltoid.

It is to be observed that the great tuberosity of the humerus is the upper part of a ridge, which, extending down as the anterior lip of the bicepital groove, widens out into the deltoid surface.

Now, as the attachment of both portions of the deltoid, and also of the great pectoral muscle, have been shown to have their homologue in the thigh-bone, forced to the inner and back part of that

bone, it will also be observed that the attachments of the homologues of the inferior spinatus and teres minor retain their attachments to the great trochanter.

It becomes, therefore, an important question to determine the homologies of the humeral tuberosities and femoral trochanters. With this view it is to be observed, that as the obturator internus would appear to be the real homologue of the subscapularis, and as the tendon of the obturator internus is attached to the fore-part of the upper margin of the trochanter major, it follows, that if we are to be guided as to the homologies of the tuberosities and trochanter by the principal homologous muscles connected with them, the trochanter major, instead of being, as is usually supposed, the greater tuberosity of the humerus, must be the homologue of the lesser tuberosity, and the lesser trochanter the real homologue of the great tuberosity. If this be admitted, then we must also admit that the homologue of the centre of ossification of the greater tuberosity of the humerus has been forced downwards, inwards, and backwards, in the direction of the anterior intertrochanteric line, and along with the linear attachment of the clavicular portions of the deltoid and great pectoral, assumed positions on the inner and posterior aspects of the thigh-bone. For physiological ends the attachments of the homologues of the inferior spinatus and teres minor retain their position at the outer and upper part of the bone; and, in consequence of the homologue of the lesser tuberosity having passed upwards and outwards, so as to take the position of the homologue of the greater tuberosity, these two muscles are secondarily attached to it.

V.—ACTION OF THE POPLITEUS MUSCLE.

This muscle takes its origin below from the tibia and the dense fascia-like prolongation of the semi-membranosus tendon, which covers it. It passes obliquely upwards, forwards, and outwards, to the depression on the outer surface of the external condyle of the femur. Its opposite points of attachment are nearer one another in the extended than in the flexed condition of the limb. Hence the muscle acts as an extensor, and not, as is usually stated, as a

flexor muscle. From the peculiar spiral form of the articular surfaces, when the knee-joint is fully extended the movement of flexion is initiated by the action of the sartorius, gracilis, and semi-tendinosus, which slightly rotate the leg and foot inwards.—(See vol. ii. p. 222.) Similarly, when the joint is fully flexed, the movement of extension is initiated by the action of the popliteus muscle, which brings the joint into the horizontal position.

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